44th annual Proceedings

Selected Research and Development Papers - Volume 1
Selected Papers on the Practice of Educational Communications and Technology - Volume 2

Presented Online and On-site during The Annual Convention of the Association for Educational Communications and Technology

Editors
Michael Simonson, Ph.D.
Fischler College of Education and School of Criminal Justice
College of Health Care Sciences
Nova Southeastern University
Davie, FL

Deborah Seepersaud, Ed.D.
Instructional Designer/Adjunct Faculty
Extended Learning
Academic Affairs
Barry University
Miami Shores, FL

Preface

For the forty fourth time, the Association for Educational Communications and Technology (AECT) is sponsoring the publication of these Proceedings. Papers published in this volume were presented online and onsite during the annual AECT Convention. A limited quantity of these Proceedings were printed and sold in both hardcopy and electronic versions. Volumes 1 and 2 are available through the Educational Resources Clearinghouse (ERIC) System. Proceedings volumes are available to members at AECT.org.

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The Proceedings of AECT's Convention are published in two volumes. Volume #1 contains papers dealing primarily with research and development topics. Papers dealing with the practice of instructional technology including instruction and training issues are contained in Volume #2. This year, both volumes are included in one document.

REFEREEING PROCESS: Papers selected for presentation at the AECT Convention and included in these Proceedings were subjected to a reviewing process. All references to authorship were removed from proposals before they were submitted to referees for review. Approximately sixty percent of the manuscripts submitted for consideration were selected for presentation at the convention and for publication in these Proceedings. The papers contained in this document represent some of the most current thinking in educational communications and technology.

Michael R. Simonson
Deborah J. Seepersaud
Editors

2021 Annual Proceedings – Volumes 1 & 2

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and
Volume 2: Selected Papers
on the
Practice of Educational Communications and Technology

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2021

Editors
Michael Simonson, Ph.D.
Professor
Instructional Technology and Distance Education
Fischler College of Education and School of Criminal Justice
Nova Southeastern University
Davie, FL

Deborah Seepersaud, Ed.D.
Instructional Designer/Adjunct Faculty
Extended Learning
Academic Affairs
Barry University
Miami Shores, FL

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Selected Research and Development Papers

Virtually a Sisterhood:
Social Connectedness and Online Collaboration

Dr. George Banks-Weston
Dr. Tammi Kolski
Curriculum and Instruction
College of Education
University of South Carolina
Columbia, South Carolina

Abstract

The purpose of this ethnographic research was to uncover the experiences of culturally diverse women participating in an online business strategy course and to evaluate the impact of virtual collaboration on social connectedness among this group. This study was situated within a national organization for women of color who are entrepreneurs. Data was collected from three members during an eight-week online course that also functioned as a virtual community of practice. Qualitative data was collected in three phases of semi-structured interviews with each participant being interviewed at the beginning, midpoint, and end of the course. Inductive analysis revealed that virtual collaboration positively impacted participants' feelings of social connectedness when activities were supported by use of virtual collaboration tools. The virtual collaboration tools allowed participants to work towards common goals, build a support network, and participate in skill development that contributed towards their career advancement.

Keywords: social connectedness, virtual community of practice, virtual collaboration tools, social capital, and women of color

Virtually a Sisterhood: Social Connectedness and Online Collaboration

Professional women of color often encounter discrimination and marginalization that negatively impacts their careers (Neville et al., 2018; Scott & Hussein, 2019). Additionally, based on their status as double minorities, these women also experience threats of being stereotyped which can leave them feeling isolated (Alfred et al., 2019; Johnson et al., 2017). Among the challenges faced by these individuals is the lack of access to support systems that provide them opportunities for mentorship, networking, and professional development opportunities (Ong et al., 2018; Rice, 2017). Research has shown that when these women have access to resources, networks, and spaces where they feel supported, understood and connected, it has a positive impact on their personal and career success (Kumi-Yeboah et al., 2017; McLoughlin et al., 2018).

The purpose of this study was to evaluate the impact of virtual collaboration on social connectedness among a group of culturally diverse women participating in an online professional development course for entrepreneurs. Social connectedness is identified as a factor in the success of underrepresented populations and past research has expressed a need for more studies centered on the professional experiences of these individuals (Ong et al., 2018). Specifically, the research question that guided this study was how does virtual collaboration impact social connectedness among a group of culturally diverse women participating in an online business strategy course for entrepreneurs.

Conceptual Framework

Social capital theory holds that social constructs impact how one views their role in a group (Bourdieu, 2011). Current research on social capital evolves this theory, identifying social capital as a construct that can be directly aligned to the social and economic well-being of individuals who belong to groups, networks, or communities (Waller et al, 2011; Zhang et al., 2011). Waller et al. (2011) highlighted that the degree of social capital's influence can be connected to an individual's perception of belonging within these groups, and how this perception impacts their connection to other individuals in this group. There is value connected to an individual's sense of belonging and subsequently their social connectedness to a group or network, with these two components often identified as the two major tenets of social capital theory (Waller et al., 2011).

When an individual has a strong sense of belonging it means they feel fully integrated into their environment and as such, can maximize opportunities to benefit from the resources of that environment. An internal form of sense of belonging is social connectedness (Costen et al., 2013). Social connectedness is centered on the opinion of one's self in relation to other people within a group or network and represents the emotional distance between one's self and other people within their network (Paolucci et al., 2021). Social connectedness is also viewed as the strength of the relationships that an individual has with others, and how these relationships influence their interactions with others in a particular network.

Social Connectedness and Underrepresented Populations

As it relates to underrepresented populations, Costen et al. (2013) revealed that social connectedness can be an influencer in an individual's ability to acclimate to an environment. Aligning with this study, Museus and Saelua (2017) highlighted that more culturally engaged climates can positively impact feelings of connectedness and belonging among underrepresented individuals in learning environments. In these environments, individuals from underrepresented populations seek out or build their own support systems (Ong et al., 2018; West, 2017, 2019). Participation in these types of support networks, also known as

counterspaces, has been shown to lessen feelings of isolation by helping women form connections with others who may also have had similar challenges with discrimination and marginalization (Johnson et al., 2017; Ong et al., 2018; West, 2017, 2019).

A high degree of social connectedness in learning environments can also have implications for an individual's success (Mishra, 2020; Museus & Saelua, 2017). Factors that positively influence social connectedness in learning environments are those that intentionally embrace diversity and inclusion as well as depth and quality of relationships with peers who share similar ethnic backgrounds (Costen et al., 2013), and support services such as counseling, coaching, or mentorship (Mishra, 2020).

With the advancement of technology, recent research has explored the role technology plays in building social capital in online environments. Much of the research showcases the ways in which individuals engage or leverage technological tools within these environments to engage with others, to find and create communities, and to learn in ways that impact or help individual's form their social identities and acquire social capital (Grottke et al., 2018; Roldan et al., 2017). As such, online interactions have implications on an individual's feelings of connectedness to other individuals in those networks. Additionally, past research on building social capital in an online forum uncovered how the use of technology, namely computer mediated communication tools, both supports and interferes with an individual's feelings of connectedness (Roldan et al., 2017).

In in-person environments an individual's feelings of social connectedness can be assessed through their perceptions of their position or belonging in that group, how they feel they demonstrate the predictable behaviors of that group, and the physical traits of the environment (Callahan et al., 2015; Irgens, 2019). However, in online environments, each of these aspects are more challenging to observe (Slagter van Tryon & Bishop, 2009). Further suggesting that enhanced feelings of social connectedness in online environments are closely tied to activities and behaviors that support collaboration, open communication, and provide opportunities to identify common goals or to share resources (Grottke et al., 2018; Mays, 2016). When these strategies and activities are leveraged in online environments and strong feelings of social connectedness are able to develop, it can be an influencer in career development, persistence, and achievement (Donelan, 2016; Heidari et al., 2020). These opportunities are often presented through the use of online social networking tools, where individuals can build formal or informal networks (Donelan, 2016; Heidari et al., 2020; Roldan et al., 2017). Through these networks, individuals can contribute their own knowledge and at the same time, learn from others, and gain access to career opportunities.

Virtual Communities of Practice & Virtual Collaboration

Lave and Wegner (1991) defines communities of practice as systems or networks where members develop a shared understanding about who they are, what they are doing, and how each of these components apply to them individually as well as within a collective community. Virtual communities of practice (VCoPs) are defined as communities where members build, share, and create knowledge in an online environment and have been heralded as vital to collective learning in a society that is more reliant on technology (Ardichvili et al., 2003; Ardichvili, 2008). Through VCoPs, those individuals who are novices can build knowledge and acquire resources from more experienced individuals (known as experts) participating in that community (Hafeez et al., 2019; Hernández-Sotoa et al., 2021).

Research of Callahan et al. (2015), Liu et al. (2017), and West (2019) suggested to combat underrepresentation and improve the retention of diverse talent in professional industries,

activities that enhance social connectedness must be integrated into virtual collaboration strategies which are essential to the success of a VCoP. Although definitions of virtual collaboration are varied, it is most commonly defined as activities or acts in a virtual environment centered around a common goal, purpose, or task (Taras et al., 2013). For purposes of this study, virtual collaboration was defined as a group of individuals working toward common goals in an online professional development environment. These common goals were supported through the use of audio-conferencing, videoconferencing, or computer-mediated technologies also known as virtual collaboration tools (Poppe et al., 2017). Several virtual collaboration strategies have been identified as relevant to knowledge sharing and learning in VCoPs. These strategies stress the importance of creating inclusive environments where all members feel they can actively participate, even though their participation is often framed as voluntary (Ardichvili, 2008; McLoughlin et al., 2018). Porter et al. (2011) identified that VCoPs are more successful in driving participation from members when those who belong to that community have role clarity and defined responsibilities. This can also include opportunities for members who are experts to provide mentorship to others (Hernández-Sotoa et al., 2021) as well as find ways to disperse knowledge creation equally across members (Barnett et al., 2016). In addition, Hernández-Sotoa et al. (2021) holds that members of the community must not only understand what their role is, but also how it aligns with the greater mission, values, and goals of that VCoP.

Methods

Approaching the research through an ethnographic lens, this study was conducted through The Prominence Association for Women (a pseudonym), a national membership organization for professional women. Founded in 2012, The Prominence Association for Women was founded to provide professional coaching, mentorship, and educational resources for women of color who were seeking to grow their career or their business. As a part of their membership in the organization, women benefited from access to a suite of online self-paced courses, one-on-one coaching opportunities with the organization's founders, and invitations to participate in specialized career and professional development programs known as Mastermind Sessions. Mastermind Sessions take place over an eight-week period at least four times per year. Each course is guided by a different theme and are designed to provide members of the organization opportunities to quickly develop and execute specific strategies for their business or to hone a specific set of skills related to growing as professionals. The topic of the Mastermind Session that underpinned this research focused on developing a growth and customer engagement strategy for an online business. The course was conducted entirely online through a mix of weekly one-to-two-hour workshops led by leaders of The Prominence Association for Women or industry experts, and involved developing and presenting a final project or presentation to the leadership team. The five free virtual collaboration tools available for the women to use in completing their final project were Zoom, Facebook Groups, Facebook Messenger, E-mail, and Google Drive. In addition to the weekly workshops, each week participants were assigned an accountability partner, who was one of their peers in the course. The Mastermind Session referenced in this study was viewed as a VCoP because all interactions occurred online and virtual collaboration tools were used to stimulate feelings of social connectedness. Being an entrepreneur and marketing professional of color, the lead researcher of this study served as a board member of The Prominence Association for Women to advance equality for the underrepresented female membership of this organization. The lead researcher also served as a facilitator of other Mastermind Sessions; however, was not the facilitator of the

professional development session for this study. While the lead researcher shared similar cultural standpoints, professional predispositions, and personal experiences of this study's participants, their internal positions did not influence the outcomes. The second author, who did not share characteristics of the study's participants, assured that bias or influenced inquiries were removed.

A purposive sampling (Etikan & Bala, 2017) of Mastermind course participants allowed for factors of race/ethnicity, age, educational background, profession, and tenure in the organization to be considered. Members participating in the online business strategy course who were with the Prominence Association for Women for less than a year were excluded from this study. At the beginning of the online business strategy course, an e-mail was sent to the nine potential participants who had enrolled in the professional development course asking for their consent to participate in the study. The three women who responded and provided consent to participate in this study offered culturally diverse backgrounds and had varied levels of experience with technology. Table 1 provides a description of each participant, aligned to their pseudonym, and includes their age, race, tenure of membership, education, geographic location and entrepreneurship business type.

Table 1

Participant Descriptions

Pseudonym (She/Her/Hers)	Age	Race	Tenure of membership	Education	Location	Business
Jordan	30's	Black	3 Years	Master Degree	New Jersey	Real Estate / Travel
Louisa	40's	Hispanic	1.5 Years	Bachelor Degree	New Jersey	Floral Design / Event Planning
Maisie	50's	Hispanic	1 Year	Bachelor Degree	Pennsylvania	Non-Profit Scholarship Fund

Data Collection and Data Analysis

Ethnography, a qualitative research method, was used to deeply understand the social and cultural life of the women in this study (Glesne, 2016). The qualitative data was collected from a three phase semi-structured interview protocol that produced thick written cultural descriptions of the women's experiences throughout the course. Interviews took place at the initiation, midpoint, and at the conclusion of the course, each lasting 30 - 45 minutes in duration. Because participants were geographically dispersed, interviews were conducted via Zoom Meeting with the lead researcher. Methods for rigor and trustworthiness included triangulation, member checking, and weekly peer debriefing with the co-researcher (Mertler, 2017). Member checking was a multistep process that began with gaining participants feedback by providing them a presentation consisting of data collected from interviews, analytical memos, and researcher notes. Next, an individualized report of their specific responses was sent via e-mail to each woman who participated in the study. Finally, a 30-minute member check discussion was scheduled via Zoom Meeting with each participant to review their feedback and ensure their experiences and words were captured correctly. Each of the three participants validated their semi-structured interview transcripts to accurately capture their interaction and offered no feedback that changed the findings of the qualitative analysis.

Utilization of Delve coding software assisted in an inductive analysis of the nine transcribed interviews. Saldaña's (2016) first and second cycle coding techniques (Structural, In Vivo, Process, Value, Pattern, and Focus Coding) resulted in 224 codes, eight categories, three themes and one assertion: Participants perceived technology can support the development of strong intimate relationships when entrepreneurs who are women share similar backgrounds, common goals, and past experiences.

Findings

The findings of this study illustrate that the participants' use of virtual collaboration tools had an impact on their personal growth and skill development throughout the course, the ways in which they interacted with others in the course, as well as the authentic connections and bonds they were able to build as a result of their participation. Participants indicated that skill development and relationship building were enhanced by synchronous one-on-one and group interaction that allowed them to engage in discussion, provide feedback to each other, and offer guidance in real time. Participants expressed those activities that supported these types of interactions also lessened the feelings of isolation they feel as women of color who are pursuing entrepreneurship. Additionally, the activities created a learning environment where they felt supported and resulted in them identifying a positive impact on their personal and career success. These findings led to the assertion that participants perceived the use of technology can support the development of strong intimate relationships between women entrepreneurs who share similar backgrounds, common goals, and past experiences. These findings align with the existing body of research on VCoPs that has revealed technology supported activities are essential to an individual's social connectedness and subsequently their engagement with other members of that community (Ardichvili, 2008; Hafeez et al., 2019; McLoughlin et al., 2018). As well, the findings also align with research on counterspaces and women of color, where social connectedness is identified as an indicator in one's ability to develop relationships, and as such, garner benefits from those relationships that are built with others in that counterspace (Johnson et al., 2017; Ong et al., 2018; West, 2019). Support for the assertion and the existing body of research was illustrated through the three themes that emerged out of the qualitative data collected: (a) Entrepreneurial Progression, (b) Richness of Synchronous Interaction and (c) Interdependence Fosters Authentic Connections.

Theme 1: Entrepreneurial Progression

Entrepreneurial progression centered on how an individual's personal history, background, and experiences as women of color who are professionals affected their participation in the online business strategy course. This included aspects of the course that impacted professional skill development and learning outcomes. Research suggested that entrepreneurs who are women often experience discrimination and marginalization in ways that can leave them feeling isolated or unsupported in their careers (Block et al., 2019; Callahan et al., 2015; Wilkins-Yel et al., 2019). Research has also shown that being provided opportunities to connect with others who share similar background and professional experiences can lessen feelings of isolation (Ong et al., 2018; Vaccaro et al., 2019), and can help them to develop and hone skills necessary to succeed in their careers (Johnson et al., 2017; Ong et al., 2018; West, 2017, 2019). In this study, entrepreneurial progression was categorized by how an individual's identity as a woman of color shaped their views as an entrepreneur, the activities these women felt contributed to their skill development, and the specific outcomes and impacts to their career development they described as a result of their participation.

The three participants in the study - Louisa, Maise, and Jordan - highlighted that they were attracted to becoming members of The Prominence Association for Women because its focus was about women of color who are entrepreneurs. Each of these women shared that they experienced feelings of loneliness, lacked a connection with like-minded female business owners who shared similar backgrounds, and had a desire for the support and encouragement that The Prominence Association for Women offered them. In fact, the desire to connect and to collaborate with other women of color was one of the leading reasons each participant was attracted to this organization. All participants described that as women of color, they had not encountered organizations like The Prominence Association for Women that allowed them to connect with like-minded business owners who share similar backgrounds. For example, Jordan in her initial interview stated, "I hadn't heard of a membership organization that was specifically for entrepreneurs who are women of color...that was founded by a Black woman... and that was really fostering this environment of collaboration and learning and growing together." This statement was similar to one by Louisa, who highlighted in her final interview that she felt less isolated and alone as a result of taking the course. Louisa said, "Being an entrepreneur is a very lonely journey…but then I was able to find another chick out there that has the same struggle. It doesn't have to be the same business, but she's living her own, same, lonely race."

While the desire to connect with other women of color who were entrepreneurs and building a support network was one of the main attractors to the organization, participants expressed that they enrolled in the online business strategy course to cultivate skills that they felt would aid them in their future success as entrepreneurs. At the onset of the course, Louisa and Maisie, expressed a lack of self confidence in the skills they felt were essential in their roles as entrepreneurs. These skills included better understanding how to market their businesses, how to communicate with customers, how to gain funding and sponsorships, and how to expand their products or services. However, as time moved forward in the course, each of the three participants expressed feelings of appreciation, confidence, and competence as it related to their skill development. Jordan stated in her final interview, "I had tried using these [content] creation tools on my own. [After the course] I was like, wow, I can't believe I did that compared to what I was creating before." By the conclusion of the study, all three participants indicated that they felt they had cultivated skills in social media, marketing and branding, and collaboration to a level where they were able to complete a variety of tasks on their own without assistance. Louisa expressed in her final interview, "Before I was intimidated...now it's like I can walk on my own, and I am a lot more tech savvy." For communications skills, specifically, all participants commented that over the duration of the online business strategy course they were able to increase their capability to communicate with their peers and pitch their business to potential investors or donors. For example, Louisa stated in her midpoint interview, "I actually feel like I'm developing better communication skills because before I just didn't have the words [to explain] or I didn't have everything in order in my brain."

In the final interviews, each of the participants shared that through working alongside and receiving encouragement from the other women enrolled in the course, that they were able to learn how to use social media tools, video conferencing, and web design technologies as well as gain access to professional and financial resources that would benefit their business. Additionally, they discussed creating a stronger network of professionals through the relationships they were able to build with one another. Maisie noted in her final interview that through the help and coaching she received from other members in the course, she was able to learn about the different types of customer relationships she needed for her business to grow.

> Building the relationships that I did with everybody and how we helped each other, there was times that I would feel stuck and didn't know what to do and they really reached out to me and helped me out a lot. Um, that meant a lot. It still means a great deal to me and you know, learning about the different relationships, the customer relationships.

These sentiments supported these findings that when women of color have access to counterspaces, they are able to gain support and mentorship that they may not have in mainstream forums.

Theme 2: Richness of Synchronous Interaction

Throughout the study the participants' experiences were explored based on how interactions occurred within a VCoP (Ardichvili, 2008; Hafeez et al., 2019). Research has shown that in VCoPs, interactions can happen using a multitude of virtual collaboration tools (Mather & Cummings, 2014; McLoughlin et al., 2018). The nature and use of these various technologies can have an impact on the value a member may glean from their participation in the VCoP (Altebarmarkian & Alterman, 2019; Barnett et al., 2012). In this study these tools supported various types of interactions including communication between members, sharing of information, and task completion. Additionally, participants were able to leverage these virtual collaboration tools for both synchronous and asynchronous interactions throughout the study.

Participants engaged in synchronous interaction through the use of technologies such as Zoom, Facebook Messenger, and through text messaging and telephone calls. However, each of these tools served different purposes for participants based on their individual needs at the time. For example, when discussing Zoom, participants highlighted a number of key benefits including the opportunity for face-to-face communication (which participants felt were more personable) as well as capabilities such as screen and desktop sharing which allowed for other participants to provide feedback on their work. Participants also discussed the value of Zoom breakout rooms for engagement in personalized small group discussions and activities. This supports research that using these synchronous tools with a collaborative purpose can often create more value in VCoP (McLoughlin et al., 2018; Wang & Huang, 2018). This value was expressed by Louisa who identified how the breakout rooms offered an opportunity for others to ask her questions or for her to express opinions that she may have felt uncomfortable asking in the larger group. Louisa stated in her midpoint interview,

> Let's say maybe a person who's more of an introvert may feel intimidated because I'm an extrovert and I got all these questions, the breakout room helped.… If I'm by myself with someone who I feel is at a plateau, then I will start asking questions...reiterating things we've learned in the course.

Outside of the weekly workshops facilitated through Zoom, participants used Facebook Messenger, text messaging, and phone calls to communicate with their assigned accountability partners and to get assistance from their peers regarding their businesses. For example, Maisie expressed a point where she was trying to find funding for her business while completing her final presentation and how she was able to leverage text messaging to accomplish this. She stated in her midpoint interview, "I texted my accountability partner to ask her about different funds that I wasn't aware of and she helped me with that..."

In addition to synchronous interactions, virtual collaboration tools can also support asynchronous interactions and have been found helpful in document editing and feedback, formal or informal discussions, or sharing resources (Antoci et al., 2012; Porter et al., 2011). In this study, the asynchronous interaction occurred primarily through Facebook Groups. Aligning with research on computer mediated communication such as discussion boards and information

sharing tools (Antoci et al., 2012; Kabilan, 2016), Facebook Groups functioned as a repository of questions and where resources were shared over the duration of the eight-week online business strategy course. Additionally, participants took advantage of Facebook Groups to engage their peers when they needed assistance, to ask questions that they felt would be beneficial to others, to provide encouragement, when they had news or information to share, or to keep up to date on content they may have missed in one of the weekly workshops. For example, Maisie noted in her final interview, "In the Facebook Group itself I would post questions or concerns if there was anything going on that I wasn't too sure of or I would help them out and encourage them." Similarly, Jordan highlighted that Facebook Groups provided her an opportunity to share resources and information that could benefit her peers. In her final interview she provided an example, "I literally went to a training and then straight from the training...I wanted to share the information with [my classmates] ...so I posted it in the Facebook Group."

Although other technologies such as E-mail, Instagram, and Canva were mentioned, as it related to asynchronous interaction they were used sparingly. In instances where they were used, they served as a way to share information or to ask a question, however, as already identified Facebook Groups was the preferred method of communication and asynchronous interaction.

Theme 3: Interdependence Fosters Authentic Connections

When an individual has a strong sense of connection to others in a specific organization or group, it can positively impact their personal and professional success (Virick & Greer, 2012; Yoon et al., 2012). During the eight-week online business strategy course used for this research, participants cited many opportunities they were given to build strong and authentic bonds and relationships. Relationships that they believed contributed to their success in the course, but also aided them in furthering their businesses. The theme of Interdependence Fosters Authentic Connections focused on the behaviors and activities that fostered these connections and how those behaviors and activities created feelings of interdependence among the participants. There were multiple occasions where the participants likened the relationships, they were building with their peers to those they had with their family. This aligns with research on social connectedness which asserts that in order for someone to feel like they belong to a group they must feel some type of connectedness, affiliation, and companionship to others (Framke et al., 2019; Irgens, 2019). Each of these feelings were expressed when participants discussed the bonds, they were building with others in their course. These bonds were initially described during the first weeks of the online business strategy course, and were revealed by all participants in both the initial and midpoint interviews. For example, Jordan, in her midpoint interview shared, "We have a sisterhood, an environment, a safe place, for Black and Brown women to come together … where our voices and frustrations can be heard. … We can work together and give each other support through hard times."

Because women of color who are professionals have experienced discrimination over the course of their academic and professional lives, this also impacts how they acculturate into new VCoPs (Ardichvili, 2008; Barnett et al., 2012). These issues are often marked by feelings of doubt, apprehension and judgement which can prevent them from fully receiving the benefits that participation in such communities provide (Hernández-Sotoa et al., 2021). Throughout this study, all three participants shared challenges they encountered or apprehensions they felt due to age, experience, and undeveloped business acumen and technology skills. For example, Maisie cited several examples where she felt uncomfortable, frustrated, or unprepared based on her lack of knowledge or capability to perform a task or participate in a discussion in comparison to her peers. However, by the end of the study each of the participants noted that being in the course

helped them to become less intimidated when using technology, and that they were all able to utilize the other woman as resources. In her midpoint interview, Maisie shared,

> I got really frustrated...and I almost started to cry... because I [didn't] know how to do a website … and I felt alone. So, when [the facilitator] came to me [to describe my website] and I said to her, I can't do this...and I [left] because I was so upset...the next day, Jenny messages me this long message and she just made my day. She's like, I know she says, this is personal for you ... just don't give up. And you know that meant a lot.

Similarly, when asked about her comfort with technology in her final interview Louisa stated, "I don't feel intimidated. I don't know everything. I'm not an expert, but...with the ladies, we can figure it out. We can pull up the YouTube, show me how to do this... but before it would stop me."

Supporting each other and working towards a common goal was another aspect that participants believed had benefited them and their business. In her final interview, Jordan provided specific examples of how this occurred,

> I've learned a lot from the other women...I've learned how to be more of a financial steward and take control of your finances, how to deal with difficult people and how to work on dealing with that difficult customer .. and still providing the utmost customer service...I've learned different technologies.

These outcomes were supported and described by Maisie and Louisa as well, and showcased how through collaborative work and mutual support, each of the participants were able to develop skills and garner resources from their participation in the online business strategy course.

Implications

With opportunities for support networks being scarce, women of color have often been forced to seek out or build their own support systems (Ong et al., 2018; West, 2017, 2019). Participation in these types of support networks, has been shown to lessen feelings of isolation helping these women form connections with others who may also have had similar challenges with discrimination and marginalization (Johnson et al., 2017; Ong et al., 2018; West, 2017, 2019). The findings of this study suggest that virtual collaboration could offer these women more access to spaces that are free of the discrimination, sexism, marginalization, and oppression they face in their day-to-day lives. The findings also infer that when these virtual settings are guided by common goals and collaborative activities and are supported by the right choice of virtual collaboration tools, that women entrepreneurs are able to develop strong feelings of social connectedness. This social connectedness can aid in building authentic, intimate relationships with each other in ways that positively impact their confidence, help to hone and develop skills for their careers, and aid them in building a network of support for their professional success (Mishra, 2020; Museus & Saelua, 2017; Ströbel et al., 2017).

In addition, the findings of this study support past research that integrating virtual collaboration tools into online learning environments can be essential to establish common goals, provide opportunities for synchronous interaction, and embed activities that allow learners to develop their technological aptitude (Mather & Cummings, 2014; Nistor et al., 2012). When learners come from underrepresented backgrounds the presence of these components can allow them to build confidence, and encourage relationship building with their peers (Mishra, 2020; Museus & Saelua, 2017). As with this study, the development of these relationships through virtual collaboration can impact social connectedness, and ultimately provide underrepresented learners who are professionals with resources, education, and the support they need to grow and

develop as entrepreneurs. When audio-conferencing, videoconferencing, or computer-mediated technologies are embedded in online professional development courses, social connectedness can be developed and can be an influencer in career development, persistence, and achievement (Donelan, 2016; Heidari et al., 2020).

Compliance with Ethical Standards

Conflict of Interest: The authors declare they have no conflict of interest.

Research Involving Human Participants: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent to Participate: Written, informed consent was obtained from individual participants included in this study. No identifying information about these participants is included in this article.

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Benefits of Video Feedback on Low Performing Female Cadets in Physical Education: An Action Research Study

John Borman, MAJ, Ed.D.
Tammi Kolski, D.E.T.
University of South Carolina

Curriculum and Instruction
College of Education
University of South Carolina
Columbia, South Carolina

Abstract

Learning novel physical motor skills can be frustrating for some cadet students in the military movement class at the academy. A lack of clear feedback further exacerbates the problem for students' skill development. This action research study examined the benefits of using video recording as augmented feedback to inform motor skill development in an applied gymnastics course at a service academy. Furthermore, it sought a more efficient method of providing female participants individualized feedback with the goal of decreasing the physical skill gap between the males and females at the academy. The primary aim was to identify the effects of video feedback on the instructor/student process for skill evaluation and skill improvement involving low female performers. The secondary aim was to examine the extent that giving video feedback promoted the ten female students' motivation to learn, use of deliberate practice, autonomy, and competence. Data analysis revealed skill improvement on at least one skill event in the participants. Findings demonstrated that students perceived video feedback as an effective method for enhancing skill improvement in gymnastics class. These findings indicate video feedback can be used to improve motivation, deliberate practice, competence, and autonomy. The ability to visualize performance cues for the students may also result in faster motor skill acquisition. The study suggests video feedback is an effective method of augmented feedback for students struggling with novel physical motor skill progressions.

Keywords: video feedback, augmented feedback, skill acquisition, female cadets, motivation, autonomy, competence

Benefits of Video Feedback on Low Performing Female Cadets in Physical Education: An Action Research Study

Within the Physical Education Department at the academy, instructors are constantly seeking improvements and efficiencies within the curriculum and program of instruction. The core physical education classes are a graduation requirement. This means that every cadet at the academy must pass these classes to obtain a commission as an officer in the United States Army (Gist, 2016). The military movement class is one of the largest hurdles for the female cadets. However, this physically demanding course is a great indicator of future success throughout the physical program at the academy. As leaders, the academy is responsible for giving purpose, direction, and motivation to their students (Baghurst et al., 2015). One of the biggest challenges is motivating lowest performers to effectively use their practice time to improve their physical skills (Ellison & Woods, 2016). One of the greatest limiting factors to skill acquisition for students is the lack of quality feedback provided during instruction (Coelho, 2019; Turner & West, 2013). Performance based feedback is a key part to effective learning. The design of this study added to the existing sports and physical education literature on the benefits of using video feedback to inform motor skill development and improve student motivation (Potdevin et al., 2018).

While female cadets only make up about 24% of the students at the academy (PAO, 2019), females account for about 40% of the low performers and failures in the military movement class. According to the end of year report (Goetz, 2020), there were 68 course failures in the academic year 2019-2020. Goetz found that female students accounted for 27 of the course failures and failed the course at twice the rate of the enrolled males. The lower performing female students struggle to score points on many of the physically demanding tasks in the course. Low performing students lack intrinsic motivation and self-confidence (Erturan & Hulva, 2019) and are therefore less likely to use their free time to work on their skills. Given the minimal time for classroom instruction and modeling (Coelho, 2019), instructors seek ways to boaster student participation and buy-in so that they benefit from the feedback provided by instructors (Chatoupis & Vagenas, 2018).

This action research case study sought a more efficient method of providing female students individualized feedback with the goal of decreasing the physical skill gap between the males and females at the academy. The purpose of this study was to determine how video feedback effects skill performance in physical education classes and the perceived benefits of video feedback for the low performing females in an applied gymnastics class. The research questions guiding this study were:

1. What are female cadets' perceptions of video feedback for skill evaluation and skill improvement?
2. How do female cadets perceive video as an additional method of feedback?
3. How do female cadets perceive video feedback as a method to promote motivation for deliberate practice?
4. How do female cadets' perceptions of their skills change when video is added as an additional method of instructor feedback?

Literature Review

The two largest factors for inability to perform gross motor skills are a lack of physical abilities (Evans, 2013) or the lack of productive feedback (Roure et al., 2019). Research of Vanderhasselt et al. (2018) suggests that gender effects the prevalence of confidence and coping skills. Furthermore, current research suggests female students are less achievement motivated

compared to male students in physical education (So-Chen et al., 2016; Ulstad et al., 2019). Consequently, female students may respond by lowering their expectations for success in challenging tasks and avoiding the stressor (Yeung, 2011). Additionally, Yeung found that female students may be inclined to try harder to overcome the difficulties they encounter in the classroom. Outcomes from traditional gender stereotypes have contradictory findings. Berlin and Dargnies (2016) found female students are more apt to cope and avoid in the presence of stressors due to a fear of failure. They reported that female students displayed greater degree of effort in challenging tasks. Vanderhasselt et al. (2018) found that emotional based coping, avoidance of problems brought about by stressful situations, predicted higher levels of anxiety and depression. Research suggests that some females appear more apt to cope and avoid due to a fear of failure.

A limiting factor to skill acquisition for students is the lack of quality feedback during instruction (Turner & West, 2013). Augmented feedback is a vital part to learning (Kangalgil & Özgül, 2018). According to Smith (2011), instructors must present augmented feedback to the learner as often and as soon as possible after an attempt to enhance the evaluation of movement and reinforce the memory representation. Providing clear and concise feedback will help students properly practice and develop the desired physical skills (Hatzipanagos & Warburton, 2009). Efficiency will generate more time to spend on skill mastery (Smith, 2011). So-Chen et al. (2016) concluded instructors need to seek efficient teaching methods to achieve course goals and to provide their students with correct information to enhance learning, behavior, knowledge, and positive student attitudes. Erturan (2014) found the nature of teaching styles, type of feedback, time spent on the task, size of the class, and the nature of learning content are the most crucial factors that are related to teaching effectiveness. In addition, instructors need to foster an effective teacher-student interaction that provides a participatory environment for all students (Griffin et al., 2013). Overall, effective feedback should increase student motivation (Cecchini et al., 2019) while giving positive reinforcement of goals (Baghurst et al., 2015) and showing the correct and incorrect actions in the execution of a skill (Hattie & Timperley, 2007). Instructor feedback enhances student learning (Sharma et.al., 2016) through an evaluation of their contributions, discrepancies, and how to fix their errors (Berlin & Dargnies, 2016).

Physical education teachers are in a unique position to capitalize on the use of video in the classroom (BenitezSantiago & Miltenberger, 2016). Potdevin et al. (2018) found video modeling and video feedback are effective tools to aid trainers. Boyer et al. (2009) examined the use of expert video modeling combined with video feedback of performance execution of three complex gymnastic skills. While the athletes were not able to achieve perfect performance during the study, the gymnasts all demonstrated increases in skill performance and improved skill retention after the intervention. Video analysis gives a degree of freedom and choice for the student's feedback reception (Laughlin et al., 2019). Students can also incorporate select peer feedback to go with the review of video recordings (Potdevin et al., 2018) to review their own trials and self-assess, thus taking charge of their learning process (Laughlin et al., 2019). Video analysis for every lesson and every skill is not practical. However, video analysis can serve as an effective tool for supporting quality instruction and assessment of skills.

Four theoretical frameworks that underpinned this research were (A) social learning theory (Bandura, 1977; Chng & Lund, 2018); (B) self-determination theory (Baghurst et al., 2015; Drost et al., 2018; Ryan & Deci, 2000); (C) motor learning theory (Schmidt, 1975; Sharma et al., 2016); and (D) theory of feminism (Avci, 2016; Corey, 2009).

Methodology

Action research design connects theory to practice and has a connection to school improvement (Mertler, 2017). This study used a mixed-methods approach utilizing data from instructor observations, pre/post-test questionnaires, semi-structured interviews, video recordings, and student self-assessments. Through extreme case sampling, the low performing female students (N=10) within the 8-week gymnastics course were provided video feedback on their graded attempts of three gymnastic skills.

Setting and Participants

The research site was a four-year military service academy. The school enrollment was 4,400 with 20% women (PAO, 2019). The study occurred during the 8-week, 19-lesson military movement course that exposed cadets to a variety of basic movement skills, with 28 physical skills being taught and tested. Each 50-minute session consisted of roughly two skills per lesson with structured time for a master demonstration, teaching the skill progression, free-practice time, and testing (Coelho, 2019). The military movement class is a graduation requirement that all students must complete during their freshman year to obtain a commission in the United States Army.

The student to teacher ratio in the class was 10:1. Each class had between 35-40 students. The average class consisted of about 30 males and 5-10 females. Extreme case sampling was used to select the lowest performing females in the class (those who actively displayed avoidance and poor coping techniques during skill practice time). Ten female students who met this criterion and were currently enrolled in the military movement course volunteered to participate in the study. There was no extra incentive to take part in the study beyond the potential benefits of the intervention. All participants returned signed copies of the informed consent prior to engaging in the study and were assigned unique IDs. The age range of the participants was 18-23 with an average age of 19.30 (SD=1.40). The majority (66.7%) of the participants were Caucasian with the remaining having a diverse mix of ethnicities. No additional demographic information was collected. The participants also described their overall fitness level at a range from *fair* to *excellent* with a median of *fair* and had no limiting physical profiles that inhibited their ability to complete the requirements of the course.

Intervention

The study coincided with an eight-week quarter of the academic year to align with a class in session. The study took place over the course of six weeks during the additional instruction time outside of the regularly schedule class time. The program of instruction for the class included additional instruction periods scheduled throughout the quarter. The purpose of the additional instruction sessions was to provide lower performing students within the gymnastics course an opportunity to practice, review video feedback on their graded attempts of three gymnastic skills to identify performance deficiencies, and retest on their class skills. The procedures for the intervention were divided into three stages: pre-test, test, and post-test.

The pre-test stage included all the activities the participants performed prior to participation in the intervention. The method of skill progression was in accordance with the instructor manual (Coelho, 2019). Participants also completed the pre-test questionnaire. The test stage began once the students had received all the lessons covering the selected skills and covered all the graded attempts during the intervention with the use of video feedback and instructor feedback to influence skill acquisition. The participants learned the performance cues of the selected skills during the class periods. The students were provided a master demonstration followed by progressions of each skill. After each graded attempt, the participants

were allowed three minutes of deliberate practice time to work on their deficiencies prior to taking their next graded attempt of the skill. Effective use of practice time during the study was defined as a participant using the practice time to actively work on any of the components of the assigned skill. Verbal cues on the points of performance that the student needed to fix to earn a higher score on the skill were provided by the instructor. The instructor also replayed video of the attempt with the student to identify performance deficiencies. Once the student felt comfortable with the skill, they were able to make one or two graded attempts with instructor feedback on each attempt. Once the attempts are made for all three skills, the final stage of the intervention, the post-test stage, occurred. At this point, the participants completed the post-test questionnaire and individually met with the lead researcher for a semi-structured interview concerning the process and the intervention.

Data Collection

This study used multiple methods of data collection including pre/post-test student questionnaires, instructor observations, semi-structured interviews, video recordings of graded attempts, and student self-assessments. All participants completed three attempts of three separate gymnastics skills: cartwheel, rope climb, and shelf mount.

Pre-Post Test. The study used the earlier work of Standage et al. (2005) and their assessment of self-determination theory in school physical education for the pre/post-test questionnaire measures of autonomy, perceived competence, and motivation. Measures of autonomy included six items that corresponded to the participant's level of familiarity and comfort with the selected skills. During the pre-test stage, prior to each attempt, students provided an estimate of their projected score on the attempt with measures of competence assessed using six items that were modified from the perceived competence subscale of the 18-item Intrinsic Motivation Inventory previously created by McAuley et al. (1989). Measures of motivation to learn were captured using 10 items, four items to assess levels of intrinsic motivation, four items to assess a lack of motivation, and two items to assess levels of extrinsic motivation. The questionnaire used a 5-point Likert scale (1= Strongly disagree to 5 = Strongly agree). Additionally, the distinct types of motivation were assessed using the Perceived Locus of Causality scale developed by Goudas et al. (1994). The nine items were divided into three subscales that examined intrinsic, extrinsic, and a lack of motivation for the military movement class. The scores from these three subscales were used as indicators for motivation. A high score in a subscale reflects a strong indication of agreement with the motivational methods. A low score in a subscale reflects a lack of agreement with the motivational method.

Instructor Observations. Observations of the participant's active use of their deliberate practice time was recorded on a researcher created data sheet. The number of practice attempts that each student took was noted on the same data sheet. Notes on whether the participant spent time viewing their video feedback again during the practice session was also captured on the data sheet.

Semi-Structured Interviews. Semi-structured, one-on-one interviews were conducted with the participants before and after the intervention. Twelve open-ended questions were used to measure the benefits the cadets identified during the intervention. The interviews also assessed how giving video feedback impacted the instructor/cadet process for skill evaluation and improvement.

Video Recordings. The instructor video recorded each graded attempt of the skills using standard video recording settings on the participant's phone to inform the student about their quality of movement during the execution of the physical task. The instructor focused the feedback on the

visual depiction of the verbal cues of the skill being tested. The participant then viewed the recording of their attempt with the instructor to identify the key areas for skill improvement. Using the video recording, the instructor visually showed the student what elements of the skill were performed correctly, incorrectly, as well as gave the participant a grade for the attempt. ***Assessments***. Cadets provided an estimate of the score they felt they would get when they performed the skill for a grade prior to each attempt execution. The students also provided a rating level to address their previous experience and comfort level with each task prior to the first attempt. The experience level was based on a 5-point Likert scale (1= *I have never heard of the exercise* to 5 = *I am an expert*). The attempt score was also collected based on the performance scores of the participants. Data for each participant was collected at the end of each session for performance on the task.

Data Analysis

The quantitative data were collected from the questionnaires and assessments. Quantitative data were analyzed to illustrate the rate of skill acquisition and improvement as well as the level of motivation of participant. The scores were analyzed for each skill using repeated measures ANOVA to investigate changes in the mean over the course of three or more points in time. A Pearson's correlation coefficient was used to measure the statistical relationships. Qualitative data was analyzed for themes through content analysis to reflect participants perceptions, feelings, attitudes, and opinions of the study's intervention.

Results

On the pre-test, measures of autonomy corresponded to the participant's level of familiarity and comfort with the selected skills. The participants indicated a median value of familiarity of slightly familiar with the cartwheel, very familiar with the vertical rope climb, and moderately familiar with the shelf. The participants indicated a median comfort level of neutral with the cartwheel, comfortable with the vertical rope climb, and uncomfortable with the shelf. The participants' self-confidence and competence responses indicate a mixed level amongst the group. Most of the group (90%) felt they would be able to perform the skills well on their third graded attempt. However, the group was split concerning their satisfaction of their performance of the skills. Only 40% of the group agreed they would be satisfied with their performance while 30% disagreed. The participants overwhelming believed the class would boost their confidence. Most of the group (90%) felt they would be confident on the skills after working on the tasks in class. When comparing their performance on the skills with their peers, only 30% of the group felt they would do well compared to their peers. The participants indicated an elevated level of support for intrinsic motivation. Nearly all participants (90%) agreed that they find "pleasure and satisfaction" in learning new things. Most of the group (90%) agreed they go to the class to "prove to themselves" they can complete the class. However, only 30% of the participants agreed that military movement class teaches "things that interest me." The participants also indicated an elevated level of support for extrinsic motivation for the course where 60% of the group agreed the course would help them "better prepare for military career." Additionally, only 40% of the group agreed that success in the class will make them "feel important." The participants also indicated a low level of support for a lack of motivation for attendance and participation in the military movement course. The bulk of the group (80%) felt like they understood the purpose of military movement and why they needed to take the course. Likewise, 70% of the group did not feel like the class was a "waste of time." However, 20% of the group agreed that they did not "understand what they are doing" in the class. Overall, the group indicated an elevated level of motivation to attend the class and saw the value and importance of taking the class.

The participants were asked to predict their attempts just prior to making each of their three video recorded attempts. The predicted scores were based on their previous exposure to the skill during the class instruction and deliberate practice sessions. The mean predicted score for all video recorded attempts of the cartwheel was 2.37 (SD=1.61). The mean predicted score on the vertical rope climb was 3.67 (SD=1.69). The mean predicted score on the shelf was 3.70 (SD=1.90). After the students provided their predicted performance scores, they completed one graded attempt of the skill. The graded attempt was recorded using the student's video recording application on their cell phone. The mean graded score for all video recorded attempts of the cartwheel was 1.47 (SD=1.53). The mean graded score on the vertical rope climb was 3.13 (SD=2.16). The mean graded score on the shelf was 3.33 (SD=2.14).

Using a repeated measures ANOVA, the findings indicate there was a statistically significant increases in scores within the group for the cartwheel and the shelf. Video feedback had a statistically significant effect on the performance of the cartwheel, $F(2, 18) = 21.50$, $p < .001$. Additionally, the participants significantly increased their performance on the shelf, $F(2, 18) = 3.58$, $p = .049$. Contrary to the cartwheel and shelf, the participants did not significantly increase their performance on the vertical rope climb, $F(2, 18) = 2.62$, $p = .10$. However, the group did increase their mean score on the vertical rope climb from their first attempt, M= 2.90, to their final attempt, M= 4.10. Moreover, the students made significant adjustments to their predicted scores on the shelf between attempts, $F(3, 27) = 4.23$, $p = .014$. The group did not make significant adjustments to their predicted scores on the cartwheel, $F(3, 27) = 2.57$, $p = .075$, or the rope, $F(3, 27) = 2.28$, $p = .10$. While the changes in the group's predicted outcomes were not statistically different for the cartwheel or rope, the difference between the predicted and actual scores for the individuals within the groups improved significantly for the cartwheel.

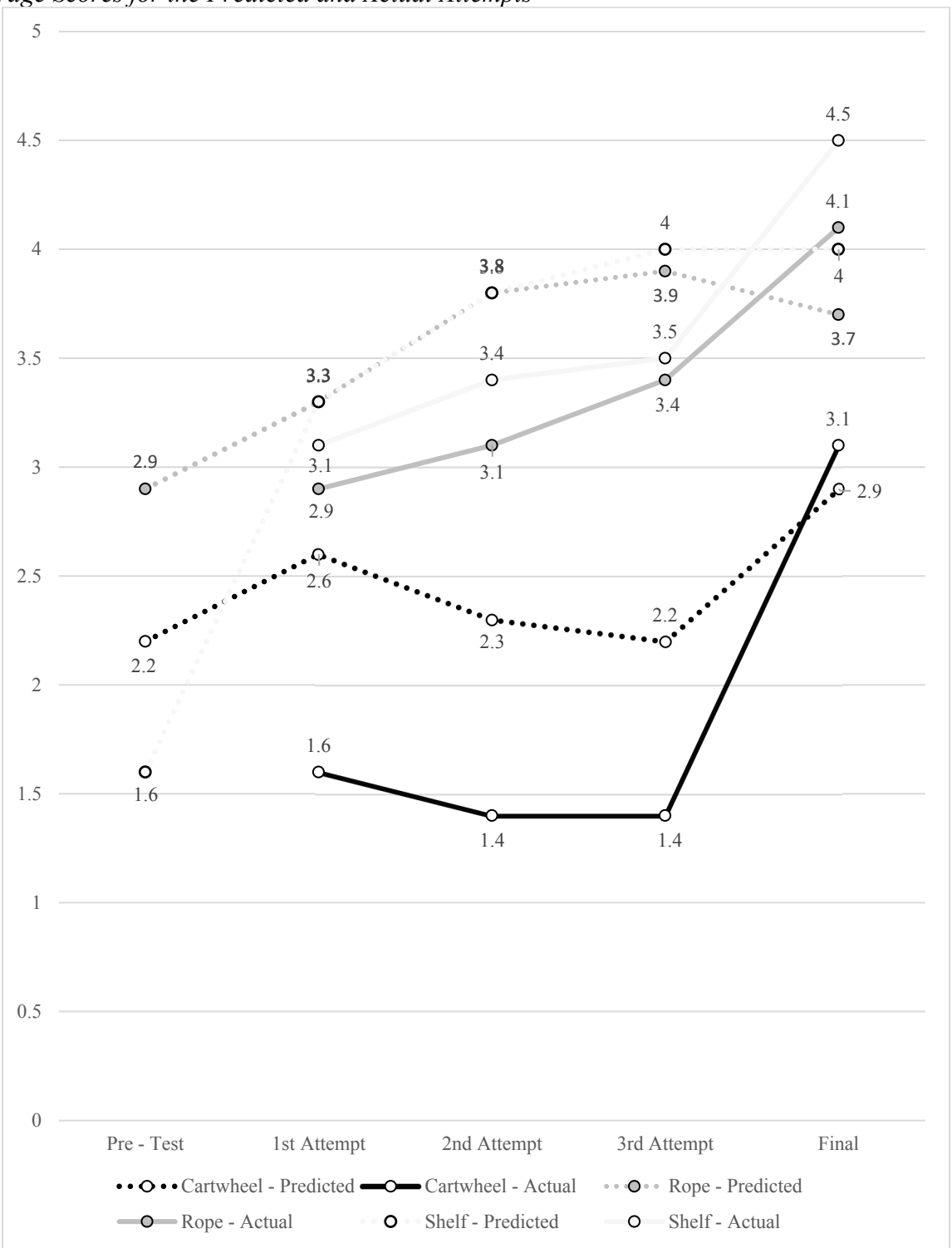
The participants overestimated their abilities on the cartwheel by an average of 1.0 point on their first attempt and underestimated themselves by an average of 0.20 points on their final attempt. The improvement in their accuracy of predictions on the cartwheel was significant, $F(2, 18) = 14.48$, $p < .001$. The participants had overestimated their abilities on the vertical rope climb by an average of 0.40 points and underestimated their skills by an average of 0.40 points on their final climb. The group did not significantly improve the accuracy of their predictions on the vertical rope climb, $F(2, 18) = 3.23$, $p = .063$. While the group did make significant changes to their predictions on their performance of the shelf, they did not significantly improve the accuracy of their predictions, $F(2, 18) = 2.16$, $p = .14$. The group went from overestimating their skills on the shelf by an average of 0.20 points to underestimating their scores by 0.50 points.

Overall, the group saw their mean scores improved in each skill. The group had a mean score increase of 1.50 (SD=.71) on the cartwheel. The group had a mean score increase of 1.20 (SD=1.69) on the vertical rope. Additionally, the group had a mean score increase of 1.40 (SD=.97) on the shelf (see Figure 1).

The Pearson's r correlation analysis for the cartwheel revealed limited correlation between the number of practices and the final score, r=0.37, as well as the relationship between practices and score improvement, r=0.52. However, for the vertical rope climb there was a strong positive correlation found between practices and score improvement, r=0.88, $p < .001$. There was minimal negative correlation found for the shelf between practices and score improvement, r=-0.19, and nearly no correlation between practices and their final score, r=-.05.

Figure 1

Average Scores for the Predicted and Actual Attempts



Data analysis revealed skill improvement in the participants. Overall, all the participants improved their task score on at least one event. Furthermore, half of the participants increased their task score on all three events. All the participants identified the video feedback as helpful

for improving at least one of their skills. Within the group, 70% of students reported an increase in perceived competence, 90% reported an increase in autonomy, and 80% of the students reported an increase in motivation. Overall, 90% of the participants recommended the future use of the video feedback in the performance of each of the performance skills.

Major themes that emerged during the qualitative data analysis included clarity of the feedback, changes in self-awareness, changes in deliberate practice, and changes in performance. The participants identified many benefits from the use of video feedback to inform their skill development. Video helped provide greater clarity for the knowledge of performance cues for the student as well as a better understanding of their deficient components of the skill. The video feedback was also shown to increase the accuracy of their predicted performance. Another significant finding from the study was the increase in self-regulation and autonomy that also lead to an increase in the use of deliberate practice time. The participants also experienced an increase in their motivation to learn while identifying support for both intrinsic and extrinsic motivational levels for the class. The study also found video feedback was beneficial for the participants' increased self-awareness and the participants preferred video feedback as their method of instructor feedback in physical education classes.

Implications for Practice

This study aimed to improve the feedback process used in the military movement class at the service academy by generating data concerning the efficiencies and effectiveness of video feedback. The findings from this study support video recordings also offer multiple benefits that could assist physical education instructors as well as students seeking a more efficient and effective feedback process. Instructors are encouraged to utilize video feedback throughout the physical education curriculum to enhance instruction for lower performers within the program. The findings of this study also suggest video feedback is an effective method of augmented feedback for students struggling with novel physical motor skill progressions. These findings demonstrated that students perceived video feedback as an effective method for enhancing skill improvement in their gymnastics class. Video feedback helped the study participants provide greater clarity for the knowledge of performance cues as well as providing them a better understanding of their deficient components of the skill. Additionally, these findings indicated video feedback could be used to improve motivation, deliberate practice, competence, and autonomy. The utilization of video feedback was shown to improve participants task scores as well as increase the accuracy of their predicted performances. Finally, the participants found video feedback to be their preferred method of feedback for learning physical skills. They found video feedback to be more beneficial than instructor verbal cues on all performed skills. The augmented feedback provided them a clear understanding of their current ability level as well as an improved understanding of the areas required to improve. Suggesting that the ability to visualize performance cues for the students may also result in faster motor skill acquisition.

Another suggestion for the implementation of video feedback is to incorporate peer feedback into the process. Allowing a partner feedback loop reduces the requirement for the instructor to serve as the lone source of feedback in the learning process. A peer could video record a practice attempt and then review the footage with the student. Reviewing the video should help students gain awareness of the key components of the skill while seeking methods for how to improve upon their deficiencies. In addition to helping reduce the time requirements of reviewing video during the class period, students could have their attempts recorded and then review the footage after class on their own time.

Limitations

The study relied on self-reported ratings for perception of feedback effectiveness. The study also included only the lowest performing female members of the class. Higher performing students may not see as much benefit from video feedback regarding their skill development or as a source of motivation. Another limitation of the study was a small sample size of ten participants which decreased statistical power of the study and is not representative of the student population at large. However, the small sample size was selected due to the population of available participants for the study. Finally, the study examined a unique population and unique set of skills. While the fitness levels of the selected participants may be below average of their peers at the academy, they have an average level of fitness when compared to their peers at other universities. The selected skills are unique to the requirements of the military academy and are not a common skill found in many physical education courses.

Compliance with Ethical Standards

Conflict of Interest: The authors declare they have no conflict of interest.

Research Involving Human Participants: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent to Participate: Written, informed consent was obtained from individual participants included in this study. No identifying information about these participants is included in this article.

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Graduate Instructors' Technostress of Engaging in Emergency Online Teaching During the COVID-19 Pandemic

Ying Cai
The University of Texas at Austin
Learning Technologies Program
Department of Curriculum and Instruction
1918 Chasewood Dr., Austin, TX 78727

Yin Hong Cheah
The University of Texas at Austin
Learning Technologies Program
Department of Curriculum and Instruction
1912 Speedway, Austin, TX 78712

Chen Meng
Indiana University Bloomington
Instructional Systems Technology Program
School of Education
2301 East 2nd Street, Apt #20, Bloomington, Indiana 47401

Jason Rosenblum
The University of Texas at Austin
Learning Technologies Program
Department of Curriculum and Instruction
1912 Speedway, Austin, TX 78712

Yi Shi
The University of Texas at Austin
Learning Technologies Program
Department of Curriculum and Instruction
1912 Speedway, Austin, TX 78712

Graduate Instructors' Technostress of Engaging in Emergency Online Teaching During the COVID-19 Pandemic

Abstract

This study investigates graduate instructors' technostress before and during the COVID-19 pandemic, and the relationship between instructors' technostress with their TPACK competencies and institutional-colleague support, respectively. Results show a significant increase in instructors' technostress level during the COVID-19 online teaching period (t (27) = -5.74, p<.01). Instructors' TPACK competencies were significantly and negatively correlated with their technostress, while the institutional-colleague support was not significantly associated with their technostress. The findings suggested that institutions may consider providing pedagogy courses, including TPACK competencies, to help graduate instructors decrease technostress.

Keywords: technostress, online teaching, TPACK, higher education

Introduction

In early 2020, most educational institutions in the United States rapidly transitioned from face-to-face instruction to online teaching due to the COVID-19 pandemic. According to Hodges et al. (2020), while this method is currently called "online teaching," it is not planned online teaching but rather a crisis-promoted emergency remote teaching, which differs from online teaching before the pandemic. This teaching method is new to most instructors, and the use of technology has become a necessity rather than an option (Özgür, 2020; Panisoara et al., 2020), which may have led to stress deriving from technology use during online teaching (Joo et al., 2016). Technostress, first introduced by Brod (1984), is defined as "a modern adaptation disorder resulting from the inability to use current computer technologies effectively" (Özgür, 2020, p. 1). While technostress research has been conducted extensively across different workplace settings, studies investigating educators' technostress are still rare (Çoklar et al., 2017). Among the few studies, Boyer-Davis (2020) discovered that college faculty suffered significantly more technostress during the pandemic than before the pandemic. Estrada-Muñoz et al. (2020) also found that during the pandemic, instructors' stress and anxiety associated with the application of educational technology grew exponentially over time. These implied that more studies are needed to understand educators' technostress to better support them in navigating the emergency online teaching.

Across the different groups of educators, graduate instructors received very little concern in educational research. But in reality, graduate instructors have become a significant teaching force for supporting undergraduate education in the United States (Douglas et al., 2016), and the preparedness of graduate instructors could directly impact the quality of education (Fong et al., 2019). Despite its significance, the support and training provided to them were quite limited (Luft et al., 2004), and few studies have been conducted to evaluate the impact of this support provided (Fong et al., 2019; Wyse, 2010). To better understand graduate instructors' teaching conditions in the United States, this study investigates their technostress levels before and during the COVID-19 pandemic and examines the factors that led to their technostress and ways to cope with it.

Literature Review

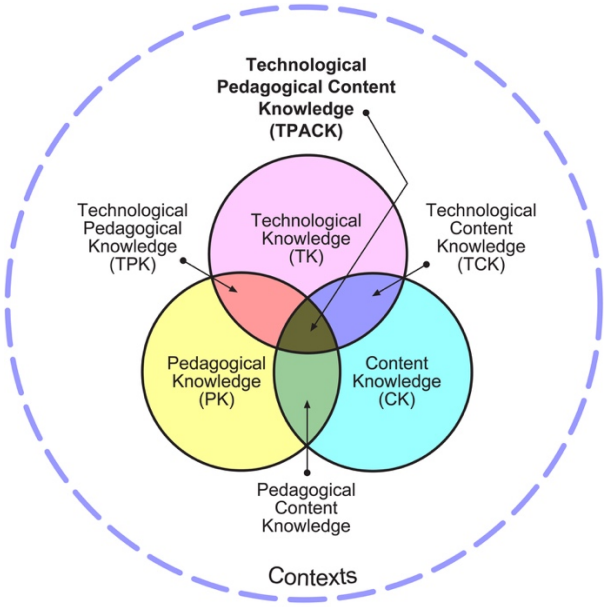
Numerous scholars have investigated factors influencing faculty's technostress in teaching. Previous literature has noted that personal and environmental factors are major ones resulted in instructors' technostress (Matthews et al., 2004; Özgür, 2020).

Personal Factors

In a study, Fuglseth and Sorebo (2014) discovered that the instructors' low-level individual ability (e.g., technological literacy, mental competencies) was an essential reason for their technostress. Some other personal factors, such as instructors' negative beliefs and resistance to applying computer technology into their teaching, were also identified by researchers (Harahap & Effiyanti, 2015). Likewise, a recent study by Zeeshan et al. (2020) examined the technostress of university faculty due to their lack of pandemic preparedness and sudden transition to online teaching during the pandemic in Pakistan. They discovered that in addition to technical issues such as internet connections, power disruptions, camera and voice quality, instructors' personal factors (including fear of using technology in class) were resulted in their technostress during the pandemic. Panisoara et al. (2020) also claimed that instructors' intrinsic motivation could effectively reduce their technostress.

Among a number of personal factors, Joo et al. (2016) proposed that teachers' competencies to teach with technology (developed from the Technological Pedagogical Content Knowledge - TPACK) are highly related to their technostress in teaching. TPACK is a framework that introduces the relationships between three basic components of knowledge (technology, pedagogy, and content) (Koehler & Mishra, 2008, 2006). Meanwhile, at the intersection of the basic knowledge are the four overlapping domains elaborate on integrating the three circles (Mishra & Koehler, 2006). In total, seven components are included in the TPACK framework (see Figure 1). Briefly, Technology Knowledge (TK) refers to the knowledge about various technologies (Schmidt et al., 2009), and Content Knowledge (CK) is the "knowledge about actual subject matter that is to be learned or taught" (Mishra & Koehler, 2006, p.1026). Pedagogical Knowledge (PK) refers to the methods and processes of teaching (Schmidt et al., 2009), and Pedagogical Content Knowledge (PCK) is the content knowledge that deals with the teaching process (Shulman, 1986). Technological Content Knowledge (TCK) is related to the knowledge of how technology can create new representations of specific content (Schmidt et al., 2009), and Technological Pedagogical Knowledge (TPK) refers to the knowledge of how various technologies can be used in teaching. Technological Pedagogical Content Knowledge (TPCK) refers to the knowledge required by teachers for integrating technology into their teaching in any content area (Schmidt et al., 2009). Many studies have been conducted to apply the TPACK framework into understanding teachers' knowledge of integrating technology into teaching (e.g., Archambault & Crippen, 2009; Hughes et al., 2020). However, since our current study focused on understanding the influence of technology-related self-efficacy for online teaching during the pandemic, only TK, TPK, and TCK were used to examine graduate instructors' technostress.

Figure 1.
The Components of the TPACK Framework (graphic from http://tpack.org/)



Environmental Factors

Previous studies (e.g., Fuglseth & Sorebo, 2014; Ragu-Nathan et al., 2008; Salanova et al., 2013) found a lack of environmental support, such as technical support, information- and communication-technology use facilitators, can result in technostress. Additionally, Al-Fudail et al. (2008) noted that the lack of fit between teachers and the technological environment, specifically, the unbalance between demands of the technological environment and teachers' abilities, as well as teachers' needs and supplies, cause instructors' technostress.

Joo et al. (2016) proposed that school support is an external factor, and the external regulation could enhance instructors' stress to a large extent (Panisoara et al., 2020). Panisoara et al. (2020) also emphasized that the school context has a significant impact on teachers' technostress. Vladut and Kallay's (2010) study found that increased school demand for technology use creates technostress among instructors. Dong et al. (2020) also identified administration support that denotes infrastructure and technical assistance and collegial support from colleagues as critical environmental factors related to teachers' use of technology.

In summary, the above research findings suggest that the major reasons for teachers' technostress include teachers' personal and environmental factors. Dong et al. (2020) framed a structural model showing the relationships among teachers' technostress, TPACK, computer self-efficacy, administration support, and collegial support. They found that TPACK can help teachers deal with psychological stress caused by technology use and suggest strengthening teachers' TPACK skills through school support and increasing teachers' computer self-efficacy. Özgür (2020) also noted a negative relationship between teachers' technostress levels and school support and TPACK competencies. TPACK negatively affects teachers' technostress, and teachers' technological integration competencies could significantly decrease teachers' technostress levels caused by ICT use during the education-training process.

Overall, limited studies have been conducted to investigate technostress among graduate instructors, the associations between their personal factors, mainly TPACK competencies and

their technostress, and the relationship between the support they have received from institutions and colleagues with their technostress; not to mention their emergency online teaching during the pandemic (Estrada-Muñoz et al., 2020). This study will contribute to the current literature and investigate graduate instructors' technostress during the pandemic.

Method

The Research Questions

1. Is graduate instructors' technostress significantly different before and during the COVID-19 pandemic when emergency online teaching began?
2. Are there any associations between instructors' TPACK competencies and their technostress regarding emergency online teaching?
3. Are there any associations between institutional-colleague support and instructors' technostress regarding emergency online teaching?

Data Collection and Participants

An online survey (see Appendix) with validated instrument items was used to answer the proposed research questions. Participants were asked to rate each item on a five-point Likert scale, ranging from one (strongly disagree) to five (strongly agree). First, participants were asked to rate their stress levels before and after classes were conducted in the online setting. A 7-item scale adopted from Panisoara et al. (2020) was used to measure technostress. An 8-item scale from Chai et al. (2011) was used to measure instructors' TK and TCK, while 4-item scale each from Panisoara et al. (2020) and Valtonen et al. (2017) were used to measure instructors' TPK and TPCK, respectively. Participants' institutional-colleague support was measured by a 6-item scale from Dong et al. (2019). The last section of the survey was about the demographic information of the participants.

The online survey was distributed to graduate instructors in a public university in the U.S. in February 2021, and 31 responses were collected. After excluding the invalid responses, 28 participants were included in this study. Descriptive demographics of the students who completed the survey are demonstrated in Table 1.

Table 1.
Participant Demographics Information

	Value	*n*	%
Demographics			
Gender	Male	8	28.6%
	Female	16	57.1%
	non-binary/not to disclose	4	14.3%
School/Department	College of Education	21	75.0%
	School of Engineering	4	14.3%
	College of Natural Sciences	3	10.7%

Data Analysis

Survey responses were analyzed using R. First, mean (M) and standard deviation (SD) were calculated to get an overall understanding of graduate instructors' technostress levels, their TPACK competencies, and institutional-college support. Then, paired-sample t-tests were used to compare their technostress before and during the pandemic. Pearson's correlation analyses were conducted to investigate relationships between instructors' technostress and their TPACK competencies, and between technostress and their institutional-colleague support.

Results

Instructors' Technostress Levels Before and During the Pandemic（RQ1）

As shown in Table 2, descriptive statistics demonstrate that instructors' technostress levels before COVID-19 pandemic (M = 2.71, SD = 0.81) were lower than when courses were transferred online (M = 3.43, SD = 0.99). The paired samples t-test result indicates that instructors' technostress levels were significantly higher after switching to online teaching (t (27) = -5.74, $p < .01$). Its effect size is 0.79 (95%CI [0.73, 0.85]), a notably large effect size (Cohen, 1992). This result suggests that graduate instructors felt much more technostress when the courses were transferred from in-person to online format.

Table 2.

Paired Samples t-test of Graduate Instructors' Technostress Before and During the COVID-19 Pandemic (n = 28)

		Mean	SD	t
Pair	Before the pandemic	2.71	0.81	-5.74**
	During the pandemic	3.43	0.99	

** $p<.01$

The Association Between Instructors' TPACK Competencies and Their Technostress Levels (RQ2)

Descriptive statistics show that instructors had different competency levels in each TPACK dimension (see Table 3), with TPK, TPCK, TK, and TCK in descending order. A Pearson's correlation between instructors' TPACK and their technostress about emergency online teaching (M = 2.75, SD = 0.98) was also conducted. As shown in Table 4, graduate instructors' technostress about emergency online teaching negatively correlated with their TK, TPK, TCK, TPCK. The effect sizes (0.49, 0.37, 0.41, 0.4) indicate that a moderate amount of the variability in instructors' technostress was explained by their TPACK competencies. These findings suggested that when graduate instructors have a higher level of TPACK competency, their technostress could be lower.

Table 3.
Descriptive Statistics of Graduate Instructors' TPACK Competency Level

Dimensions	Mean	SD
Technological Knowledge (TK)	3.90	0.93
Technological Pedagogical Knowledge (TPK)	4.07	0.72
Technological Content Knowledge (TCK)	3.50	0.82
Technological Pedagogical Content Knowledge (TPCK)	3.96	0.81

Table 4.
Pearson's Correlation for Graduate Instructors' TPACK and Technostress

Variable	Technostress
Technological Knowledge (TK)	-0.70**
Technological Pedagogical Knowledge (TPK)	-0.61**
Technological Content Knowledge (TCK)	-0.64**
Technological Pedagogical Content Knowledge (TPCK)	-0.63**

** $p<.01$

The Associations Between Institutional-colleague Support and Instructors' Technostress (RQ3)

Regarding environmental support, instructors received nearly equal support from institution (M = 3.81 SD = 0.59) and colleagues (M = 3.82, SD = 0.98). 22 (78.6%) participants "agreed" or "strongly agreed" that their college or school provides enough infrastructure and resources for them to do well with online teaching, while 15 (53.6%) participants "agreed" or "strongly agreed" that their college or school provides clear guidelines about online teaching. Regarding support from colleagues, 21 (75.0%) "agreed" or "strongly agreed" that they and colleagues made a connected effort to integrate technology into online teaching; 17 (60.7%) agreed or "strongly agreed" that they received encouragement from colleagues when they encountered difficulties integrating technology into their online teaching.

However, Pearson's correlation analysis indicated that there were no significant correlations between the institutional (r =0.12, p>.05) and colleague support (r =0.253, p>.05) with instructors' technostress about emergency online teaching.

Discussion

Technostress Levels and TPACK Competencies

Our study analyzed graduate instructors' technostress levels before and during the pandemic. It discovered that graduate instructors' technostress levels significantly increased when the courses were transferred from an in-person to an online format during the pandemic. In previous studies, the demand for a technological environment in the teaching context was an important factor that triggered instructors' technostress (AI-Fudail & Mellar, 2008; Panisoara et al., 2020). In this study, the transition from a familiar teaching format (i.e., in-person teaching) to online teaching during the COVID-19 pandemic was an external regulation and requirement for the graduate instructors, and they had little time to prepare themselves for this change in the teaching environment. Hence, it is not surprising that the graduate instructors experienced higher technostress levels after switching to online teaching.

Additionally, their technostress levels were significantly negatively correlated with their TPACK competency levels. As Özgür (2020) pointed out, instructors' technostress levels are determined by their abilities and competencies in using technology, and teachers' TPACK competencies greatly decrease their technostress levels. The significant negative correlations between graduate instructors' technostress levels and their TPACK competency levels found in the current study align with the previous literature showing that teachers' TPACK competencies could contribute to decreasing their technostress levels. This finding indicates that graduate instructors' TPACK competencies play an important role in helping them cope with technostress, a result similar to those in previous studies (e.g., AI-Fudal & Mellar, 2008; Joo et al., 2016). Among the TPACK dimensions, TK was found to be most negatively correlated with graduate instructors' technostress (see Table 4); thus, improving graduate instructors' technological literacy could help decrease their technostress. Also, because TK was not content- or subject-related, a general technology training workshop on integrating technology into teaching could benefit graduate instructors.

Institutional-colleague Support and Instructors' Technostress

Our findings suggested that only half of the graduate instructors agreed or strongly agreed that their college or school provides clear guidelines for online teaching, indicating that they did not get enough support from their institutions. The graduate instructors who participated in our study also pointed out the importance of getting support from peers, suggesting collaborative work among graduate instructors on integrating technology into teaching. However, our findings indicated that the support graduate instructors received from institutions and colleagues did not significantly correlate with their technostress. The significant correlations between graduate instructors' TPACK competencies and their technostress, and no significant correlations between the supports graduate instructors received from the environment and their technostress, suggested that the personal factors played a more influential role in determining graduate instructors' technostress. Thus, a more effective and practical way to reduce graduate instructors' technostress could be to improve their TPACK competencies.

Current literature has suggested that the pedagogy course can consistently increase graduate instructors' confidence and attitudes toward teaching (Fong et al., 2019). The findings of our study could contribute to the current literature and expand their suggestion that the TPACK competencies should be an essential component in the pedagogy course for graduate instructors. Dong et al. (2020) proposed that institutions should create more opportunities for

teachers to accumulate hands-on experience and provide timely feedback to improve teachers' perceived knowledge and abilities and reduce their technostress (Xie et al., 2017). They also suggested that mutual collaboration among colleagues effectively enriches instructors' development of TPACK better than providing sufficient infrastructure and technical training. Based on our findings, we also indicated that for the graduate instructors, the collaboration-based learning in a pedagogy course could also benefit them to gain knowledge and reduce technostress.

Conclusion

Graduate instructors provide instruction for many university classes. They have become an increasingly indispensable part of the teaching group; however, the current literature has not thoroughly investigated these young instructors' technostress. Our findings suggest that developing graduate instructors' TPACK competencies is a viable way to reduce technostress caused by the rapid move to online teaching. This study has practical implications for institutions supporting graduate instructors, in particular, providing courses for graduate instructors to improve their teaching ability and TPACK competencies. This study has limitations. Because it is small in scale and the participants were recruited from one university, our conclusions need to be further tested in larger-scale studies and other higher education contexts.

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Appendix

Survey

1. Please rate your stress level before Spring break 2020, when classes were conducted in a face-to-face setting. (Extremely high/High/Medium/Low/Not at all)
2. Please rate your stress level after Spring break 2020, when classes were conducted in an online setting. (Extremely high/High/Medium/Low/Not at all)
3. Please respond to the items below based on your feelings about the emergency online teaching during COVID-19 pandemic. (strongly disagree/disagree/neutral/agree/strongly agree)
    a. I feel stressed while adapting myself to online teaching.
    b. I find it difficult to use digital technology effectively for online teaching due to my limited time availability
    c. I feel stressed by the high technical requirements that are necessary for online teaching.
    d. I find it difficult, with my current skills, to constantly improve the act of online teaching
    e. I feel that online teaching complicates my teaching activity.

f. It is hard for me to concentrate on teaching with the use of different digital tools in the online setting.

g. I hesitate to incorporate other digital tools during online teaching for fear of making mistakes.

h. I am worried that online teaching will compromise student learning quality.

4. Please answer the following questions about your technological knowledge for teaching online.

a. I know how to solve my own technical problems for online teaching.

b. I can learn technology easily to serve the purpose for online teaching.

c. I keep informed about new digital technologies about online teaching.

d. I have the technical skills to use technology effectively for online teaching.

5. Please answer the following questions about your technological pedagogical knowledge for teaching online.

a. I can help my students use online learning environments (e.g., Canvas, Google applications) effectively.

b. I can design lessons/courses that enhance the online teaching approaches.

c. I can use appropriate digital conferencing technologies (e.g., Zoom, Skype, Google Meet, WebEx etc.), which allow me to communicate and interact synchronously with other colleagues or students.

d. I can use online tools to assess students' knowledge.

6. Please answer the following questions about your technological content knowledge for teaching online.

a. I know digital technologies which I can use to illustrate difficult contents in my online course.

b. I know websites with content materials for studying my online course.

c. I know how to decide on the technologies that will enable students to learn the contents of my online course in a meaningful way.

d. I can use the software that are created specifically for my online course. (e.g., e-dictionary/corpus for language; Geometric sketchpad for Math; Data loggers for Science).

7. Please answer the following questions about your technological pedagogical content knowledge for teaching online.

a. In teaching a specific online course, I know how to use digital technology as a tool for students to plan their own learning.

b. In teaching a specific online course, I know how to use digital technology as a tool for students' collaborative learning.

c. In teaching a specific online course, I know how to use digital technology as a tool for students' creative thinking.

d. In teaching a specific online course, I know how to use digital technology as a tool for students' critical thinking.

8. Please answer the following questions about <u>the ways you have been supported</u> for the emergency online teaching during COVID-19 pandemic.

a. My college/school provides clear guidelines about online teaching, so that I know how to guide student learning

b. My college/school provides sufficient training so that I know how to implement online teaching

c. The requirement and timetable for implementing online teaching is reasonable in my college/school so that I can at my own pace

d. My college/school provides enough infrastructure and resources so that I could do well on online teaching

e. I get encouragement from my colleagues when I encountered difficulties in integrating technology in online teaching

f. My colleagues share useful resources with me for online teaching

g. My colleagues share their experience with me about integrating technology into online teaching.

h. My colleagues and I made a concerted effort to integrating technology into online teaching

9. What is your gender?
10. What college/school are you in?
11. How long have you been teaching in higher education?

From Policing to Learner Analysis: Use of ExamSoft Snapshots to Analyze Students' Exam Taking Behaviors in Live and Online Exams

Dan Cernusca, Ph.D.
North Dakota State University, College of Health Professions, School of Pharmacy

Abstract

A Doctor of Pharmacy program is using a specialized examination software, ExamSoft® to addesss accreditation requirements. The primary objective of this study was to use ExamSoft snapshots log to provide empirical evidence of exam taking behaviors and the potential impact of the pandemic context on exam taker behaviors across different examination contexts. Significant behavioral differences were found between high and low achieving students as well as between face-to-face and online live monitored exams.

Motivation and Objective of the Study

The use of multiple-choices exams combined with the introduction of computer-testing platforms increased educational researchers' interest in test-taking behaviors, changes in these behaviors, and their relationships with the assessment activities (Olev & Must, 2013; Plake & Wise,1988; Tamowsky, 1977). As interest in test-taking behaviors increased, researchers started to focus on more specific impact areas such as the potential impact of test-taking behaviors on students' cognitive test performance (e.g., Heinonen et al., 2011), the role of self-efficacy in mediating the impact of test-taking behaviors on test performance (e.g., Birenbaum & Alhija, 2013), or the association between test-taking behaviors and test performance for students with special needs (e.g., Pohl et al., 2016).

Pharmacy programs are required by an accreditation agency to provide specific data to support students' progress (ACPE, n.d.). To address these requirements, a PharmD program began using a specialized examination software, ExamSoft®, that allowed instructors to link learning objectives and outcomes to assessment items. ExamSoft was integrated with the learning management system and provided valuable statistical data used to monitor the quality of individual exams items and the whole exam. ExamSoft includes security features such as device lock during the exam, item randomization, and snapshots that record all choices students make during an exam.

The primary objective of this study was to analyze students' snapshots and provide empirical evidence of exam taking behaviors, their potential relationship to the exam performance, and the potential impact of the pandemic context on exam taker behaviors.

Context of the Study

At the beginning of Fall 2020 the university set up pandemic restrictions that allowed both a mixed-attendance and a fully synchronous online attendance option. Both students and the instructor had the option to use either the face-to-face or online format of the course. For live attendance and examination options, the classroom seating capacity was limited and face masks were required.

To address the needs of fully online students, ExamSoft Exam Integrity functionality offered strong security options including offline video, audio recording, and flagging of potential breaches of integrity. For the target pharmaceutical course, in the first half of the semester, when COVID 19 pandemic restrictions were more relaxed the course was live and additional classrooms accommodated a live first exam for the entire class. For the second part of the course, the conditions worsened and the instructor decided to teach and administer the second examination fully online for the entire class. This situation offered a unique opportunity to analyze the exam taking behaviors of the same group of students both in the live and online context and analyze the potential impact of the pandemic-related conditions on the examination process.

Research Focus and Methodology

Research Design

We used a sequential mixed-methods design that built on a qualitative analysis of the raw ExamSoft data to identify significant examination behaviors followed by a comparative qualitative analysis of the identified significant exam-taker behaviors. The dependent variables used in this study were behavioral patterns, assessment item difficulty, and the maximum number of choices an exam taker made for each assessment item throughout the examination period. The independent variables were grade level (high, within top 20% of the exam grades or low, within the bottom 20% of the grades), nature of the exam (face-to-face or online with digital exam monitoring), and the correctness of the final answer (correct or wrong).

Data Collection

ExamSoft records the entire activity of the exam taker during the exam in what is known as “Exam Taker Snapshots”. This detailed information was intended to serve as a means to provide support for the instructor when checking and identifying potential attempts of cheating. While this “policing” tool is considered a needed and useful security feature, the Exam Taker Snapshots (or simply ExamSoft snapshots) can also provide support for tracking students’ observed exam-taking behaviors (Cernusca & Friesner, 2019). That is, for multiple-choice assessment items ExamSoft snapshots include all choices students made (e.g., view an assessment item, select a specific answer, change a previously selected answer) and the time-stamp associated with each choice.

The ExamSoft snapshot logs are available through the software interface (Figure 1) and allow for basic sorting of the information by assessment item or time stamp. However, the ExamSoft snapshot logs can also be downloaded as an Excel spreadsheet and used for further more detailed analyses.

Figure 1

Sample Snapshot Viewer in ExamSoft

Snapshot Viewer

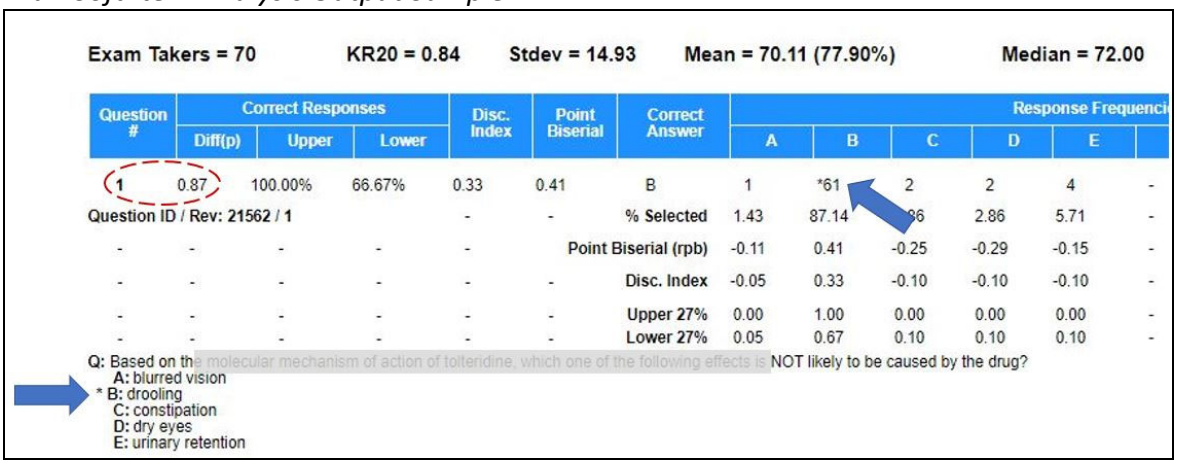
Previous 1 2 Next Show: 50 | 250 | 500 | 1000 | 2500

Item #	Snapshot #	Item Type	Time Stamp	Trigger	Response
1	1	Choice	5:05:30 PM	Answered	Choice(s): E
2	1	Choice	5:15:14 PM	Navigation	Choice(s): C
3	1	Choice	5:12:30 PM	Answered	Choice(s): E
4	1	Choice	5:12:16 PM	Answered	
5	1	Choice	5:13:30 PM	Answered	
6	1	Choice	5:04:12 PM	Exam Start	
7	1	Choice	5:24:30 PM	Answered	Choice(s): C
8	1	Choice	5:06:19 PM	Answered	
9	1	Choice	5:22:30 PM	Answered	Choice(s): C
10	1	Choice	5:17:30 PM	Answered	Choice(s): B
11	1	Choice	5:23:30 PM	Answered	
12	1	Choice	5:09:30 PM	Answered	

Question numbering in the snapshot reflected the default organization of the exam even when questions were randomized. The spreadsheet format of the snapshots allowed for the organization of choices by question number and time stamp to reflect the exam taker behaviors for each question. In addition to the snapshot viewer the item analysis output from ExamSoft provided the correct answer and assessment item difficulty (Figure 2)

Figure 2

ExamSoft Item Analysis Output Sample



Exam Takers = 70 KR20 = 0.84 Stdev = 14.93 Mean = 70.11 (77.90%) Median = 72.00

Question #	Correct Responses			Disc. Index	Point Biserial	Correct Answer	Response Frequenci					
	Diff(p)	Upper	Lower				A	B	C	D	E	
1	0.87	100.00%	66.67%	0.33	0.41	B	1	*61	2	2	4	-
Question ID / Rev: 21562 / 1				-	-	% Selected	1.43	87.14	2.86	2.86	5.71	-
-	-	-	-	-		Point Biserial (rpb)	-0.11	0.41	-0.25	-0.29	-0.15	-
-	-	-	-	-	-	Disc. Index	-0.05	0.33	-0.10	-0.10	-0.10	-
-	-	-	-	-	-	Upper 27%	0.00	1.00	0.00	0.00	0.00	-
-	-	-	-	-	-	Lower 27%	0.05	0.67	0.10	0.10	0.10	-

Q: Based on the molecular mechanism of action of tolterodine, which one of the following effects is NOT likely to be caused by the drug?
A: blurred vision
* B: drooling
C: constipation
D: dry eyes
E: urinary retention

Participant Selection

The snapshot of seven high performers that were placed in the first 20% of the class and seven low performers placed in the lower 20% of the class from both live and online exams were selected for this research study.

This number of participants was considered optimal considering that each exam used for this study had between 35 and 50 assessment items and for each assessment item the ExamSoft snapshot log recorded between two and 10 behavioral actions.

Data Analysis

Data analysis involved a qualitative phase that helped identify significant behavioral patterns and a quantitative phase where identified behavioral patterns quantified and used for statistical analysis using SPSS® (https://www.ibm.com/products/spss-statistics) statistical software.

Qualitative Analysis Phase

The structure of the ExamSoft Snapshots allowed for a qualitative analysis of the observed exam taking behaviors followed by grouping of these behaviors into specific behavioral patterns. As a first step in the qualitative analysis the snapshot Excel output was organized by assessment item and then by the choice (recorded exam taker action). The first choice for each assessment item was then color coded and a column with the correct answer for each item was added to help analyze the sequence of the choices made by the exam taker (see Figure 3).

Figure 3
ExamSoft Snapshots Organized by Item and Choice

	Item#	Snapshot#	Item Type	Time Stamp	Trigger	Response	correct_answer
2	3	1	Choice	4:04:43 PM	Answered		A
3	3	2	Choice	4:14:16 PM	Answered	Choice(s): A	
4	3	3	Choice	4:33:04 PM	Final	Choice(s): A	
5	4	1	Choice	4:09:16 PM	Answered	Choice(s): A	C
6	4	2	Choice	4:33:04 PM	Final	Choice(s): A	
7	5	1	Choice	4:05:11 PM	Answered		A
8	5	2	Choice	4:14:36 PM	Answered	Choice(s): A	
9	5	3	Choice	4:33:04 PM	Final	Choice(s): A	
10	6	1	Choice	4:07:18 PM	Answered	Choice(s): C	C
11	6	2	Choice	4:33:04 PM	Final	Choice(s): C	
12	7	1	Choice	4:11:31 PM	Answered		A
13	7	2	Choice	4:29:29 PM	Answered	Choice(s): D	
14	7	3	Choice	4:33:04 PM	Final	Choice(s): D	
15	8	1	Choice	4:03:43 PM	Answered	Choice(s): A	A
16	8	2	Choice	4:22:48 PM	Answered	Choice(s): B	
17	8	3	Choice	4:33:04 PM	Final	Choice(s): B	
18	9	1	Choice	4:04:22 PM	Answered	Choice(s): D	D
19	9	2	Choice	4:33:04 PM	Final	Choice(s): D	
20	10	1	Choice	4:04:15 PM	Answered	Choice(s): C	C
21	10	2	Choice	4:33:04 PM	Final	Choice(s): C	

This structure of the snapshot log allowed to identify several micro-behaviors: viewing a question without selection, selection of an answer, change of an answer from correct to wrong, or change of a wrong answer to a correct one. These micro-behaviors were then used to defined 10 overall behaviors that reflected potential sequencing across observed exam taker choices for the dataset used in this study. Examples of these behaviors include: correct answer from first choice to the final choice; view without a choice then correct answer to final choice; wrong answer as the first choice then correct answer to final choice; or wrong answer at the first choice, changed to correct answer and then wrong answer to final choice. The identified basic behaviors were mixed into behavioral patterns that included repetitive patterns. For the scope of this study, the behaviors were grouped in four outcomes, two beneficial and two damaging.

The two beneficial behavioral patterns were:

(b1-cc) correct - correct, correct answer from the beginning to the end of the exam

(b2-wc) wrong - correct, wrong answer in the beginning changed into a correct answer by the end of the exam.

The two damaging behavioral patterns were:

(d1-cw) correct - wrong, correct answer in the beginning changed to a wrong answer

(d2-ww) wrong - wrong, wrong answer from the beginning to the end.

Qualitative Analysis Phase

For the quantitative phase of the analysis, two exams in the same course that were administered during the COVID-19 pandemic were considered for this study. The first one was administered during the first stage of the pandemic when the face-to-face attendance was acceptable with distancing and class occupancy and masking requirements were strictly observed. The second exam was administered at the time when the pandemic requirements were tightened and remote instruction was in place. For each of the exams, seven high achieving students placed in both exams within top 20% of the grades as well as seven low achieving students placed within the bottom 20% of the scores were selected for this study. For each exam each student's snapshots were coded at the assessment item level for the four observed behavioral patterns identified in the previous step and then the percentage of each behavior relative to the total number of assessment items was computed.

In the next step, a synthesis Excel spreadsheet was created by recording for each student the percentages for each of the four observed behavioral patterns computed in the previous step, the maximum number of choices, the correct/wrong answer code, the grade level and the exam code (1-live, 2-remote). Figure 4 shows a snapshot of the synthesis Excel spreadsheet generated and used for this phase of the data analysis.

Because of the small number of participants, a non-parametric test, Kruskal-Wallis, was used to compare the considered dependent behavioral variables and number of choices by exam type and respectively achievement/grade level.

Figure 4

Synthesis Spreadsheet for Statistical Data Analysis

1	StudID	ex_id	grade_level	b1_cc	b2_wc	d1_cw	d2_ww	max_choices
2	fs20_413_ex1_live_high_1	1	1	96.43	0.00	0.00	3.57	3
3	fs20_413_ex1_live_high_2	1	1	96.43	0.00	0.00	3.57	3
4	fs20_413_ex1_live_high_3	1	1	96.43	0.00	0.00	3.57	3
5	fs20_413_ex1_live_high_4	1	1	96.43	0.00	0.00	3.57	3
6	fs20_413_ex1_live_high_5	1	1	89.29	3.57	0.00	7.14	4
7	fs20_413_ex1_live_high_6	1	1	100.00	0.00	0.00	0.00	3
8	fs20_413_ex1_live_high_7	1	1	82.14	7.14	0.00	10.71	10
9	fs20_413_ex1_live_low_1	1	2	46.43	14.29	3.57	35.71	4
10	fs20_413_ex1_live_low_2	1	2	32.14	21.43	28.57	17.86	4
11	fs20_413_ex1_live_low_3	1	2	64.29	0.00	0.00	35.71	3
12	fs20_413_ex1_live_low_4	1	2	50.00	7.14	7.14	35.71	5
13	fs20_413_ex1_live_low_5	1	2	46.43	7.14	7.14	39.29	5
14	fs20_413_ex1_live_low_6	1	2	53.57	3.57	7.14	35.71	5
15	fs20_413_ex1_live_low_7	1	2	60.71	0.00	3.57	35.71	4
16	fs20_413_ex2_rem_high_1	2	1	89.66	6.90	0.00	3.45	7
17	fs20_413_ex2_rem_high_2	2	1	68.97	31.03	0.00	0.00	10

Findings

When the observed beneficial behavioral patterns were analyzed by the student achievement levels, a Kruskal-Wallis test indicated that high achieving students ranked statistically significant higher in beneficial correct-correct behavioral pattern (21.5) than low achieving students (7.5), $H(1) = 20.37$, $p < 0.001$. However, the two groups ranked about the same in beneficial wrong-correct behavioral pattern ($p = .0.083$).

For the damaging behavioral patterns, the Kruskal-Wallis test indicated the same type of differences between low and high achieving students:

- for damaging correct-wrong behavioral pattern the low achieving students ranked statistically significant higher (20) than high performing students (9), $H(1) = 16.16$, $p < 0.001$;

- for damaging wrong-wrong behavioral pattern, the low achieving students ranked statistically significant higher (21.5) than high performing students (7.5), $H(1) = 20.59$, $p < 0.001$;

When only the high achieving students were considered for the analysis, a Kruskal-Wallis test indicated a statistically significant higher ranking only for damaging wrong-wrong behavioral pattern during the live exam (10.1) when compared to the remote exam (8.9), $H(1) = 6.04$, $p < 0.05$. No statistically significant differences were found for the two positive behavioral patterns and second damaging behavioral pattern (correct-wrong).

However, when only the low achieving group was considered for the analysis, the Kruskal-Wallis test indicated:

- a statistically significant lower ranking for correct-correct beneficial behavioral pattern for the remote exam (4.4) when compared to the live exam (10.6), $H(1) = 7.65$, $p<0.01$, and respectively

- a statistically significant higher ranking for wrong-wrong detrimental behavioral pattern for the remote exam (11) when compared to the live exam (4), $H(1) = 10.27$, $p<0.01$. No statistically significant differences for the beneficial wrong-correct and detrimental correct-wrong behavioral patterns between the two types of exams.

Finally, when the maximum choices by question were analyzed across the two types of exams (live and remote), the Kruskal-Wallis test indicated a statistically significant ranking for the remote exam when compared to the live exam for both the high achieving group ($p<0.05$) and the low achieving group ($p<0.01$).

Discussions

By expanding the use of ExamSoft snapshots from exam security purpose to the analysis of exam taker behaviors we were able to identify behavioral patterns and their variation across student achievement levels and across different examination contexts. The findings from this study indicated that, as expected, high achieving students made better answer choices and these choices were reflected in more beneficial outcomes while the low achieving students had behaviors that resulted in an increased level of damaging outcomes.

When students were placed in an online exam format due to the COVID 19 pandemic-related constraints, students in low achieving group were more likely to exhibit behaviors that decreased the beneficial outcomes and increased the damaging ones. Finally, we found that during the online examination students in both achievement groups made more maximum choices by exam questions which can be explained through a combination of a potential increase in the level of anxiety and less distractions during the exam compared to the face-to-face context. However, additional research is needed to analyze the factors that impact, positively or negatively, assessment in a remote testing format.

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A Restorative Leadership Training Model Isn't Just for Mock Trial Training.

Anetta R. Dolowitz, MSW, MPH, PhD Student
University of South Alabama

Shenghua Zha, PhD
University of South Alabama

Brandon L. Blankenship, JD
University of Alabama at Birmingham

Abstract

A mixed-methods collective case study was conducted to assess how training and accompanying instruments impact teams' implementation of Restorative Leadership skills in competitive and noncompetitive settings. Using a parallel mixed methods hybrid design where focus groups, mixed-methods surveys, observer checklists, one-on-one interviews, quizzes, and self-assessment checklists were used to address five research questions. Nine noncompetitive teams in two honors classes, a mock trial team, and an assistant mock trial team coach from a medium Southeastern university participated in this study. The nine noncompetitive teams were assigned to watch instructional videos about Restorative Leadership touchstones and were required to complete a 10-question quiz, followed by a voluntary Qualtrics mixed survey to get feedback on two restorative skills checklists. A leaderboard (dashboard) was implemented in the competitive mock trial team setting with two teams (Gold Team, Green Team). The purpose of this study was to determine if current Restorative Leadership instruction and accompanying tools can successfully aid both competitive teams and noncompetitive teams to implement Restorative Leadership skills in various activities. The results indicated positive support for the checklists to assess the application of Restorative Leadership skills for noncompetitive teams and mixed results for the impact of a leaderboard on individual and team performance for competitive teams.

1. Introduction:

What would it be like to create a model of leadership that could improve communication, accountability, and team relationships in a post-pandemic workplace? Where would we begin? Law schools across the country have primarily used the Case Method since 1890 to train teams for competitions (Chisholm, 1911). However, team cohesion, a key component in the success of team competition, has been undermined in traditional team training (Salas et al., 2015). Studies have shown that training focused on restorative leadership training improved participants' communication, accountability, and relationship with other team members (Blankenship, Mwenja, Dolowitz & Wech, 2021; Pointer, 2019). Currently, the definition of restorative leadership is a work in progress that centers around four core tenets: working together to achieve invitation over coercion, radical inclusion, equitable communities, and working together to achieve objectives

(Blankenship, et al., 2021). The heart of restorative leadership is the push to help teams address challenges that naturally occur within a team over time. Yet the problem is how to offer restorative leadership training effectively. A recent study by Vegt, Visch, Vermeeren, and Ridder (2018) showed that gamification with team performance components was associated with increasing team cohesion.

In this study, we introduced a new restorative leadership training model in several courses and examined its effectiveness on participants' performance. This model was featured with gamified team strategy and restorative leadership training. The research questions were:

1. How effective was the restorative leadership training in helping participants apply the skills in application exercises?
2. How did the use of the gamified team strategy impact participants' individual performance?
3. How did the use of the gamified team strategy impact team performance?
4. How did the use of gamified team strategy influence participants' preparedness for class?
5. How did the dual assessments impact participants' performance?

2. Research Design

This was a parallel mixed method collective case study. For the qualitative analysis, we examined four different cases simultaneously. We examined how teams implemented the Restorative Leadership model in team activities through self-assessments, observation of other teams, focus group interviews, and surveys. We used the quantitative analysis to examine the impact of the Restorative Leadership training model on participants' performance, looking at the certificate completion, the self-assessment checklist, and individual quiz results. Qualitative results from the focus groups were used to supplement the results of quantitative analysis.

2.1 Participants. Forty-seven undergraduate students in nine noncompetitive teams (23 in an honor's college honor's course with four teams, and 25 in a business honor's course with five teams) and 30 participants, of which 17 were active on two competitive teams according to the final leaderboard, at a midsized Southeastern University in the U.S. participated in this study. The students were primarily juniors and seniors. Participants in the focus groups were from these samples. The Gold Team focus group had three participants, the Green Team had four participants, and the honor's college course focus group ended up being an individual interview. One individual interview was conducted with the Gold Team's assistant coach, a former Gold Team member.

2.2 Intervention. Participants who were from the honors courses received the Restorative Leadership training. Students from the mock trial teams were divided into two teams: Gold and Green teams. The Gold Team were students who received the gamified team strategy and participated in mock trial as an extracurricular activity. The Green Team included students who only received the gamified team strategy in training, where participation on the mock trial team was part of their grade for their course.

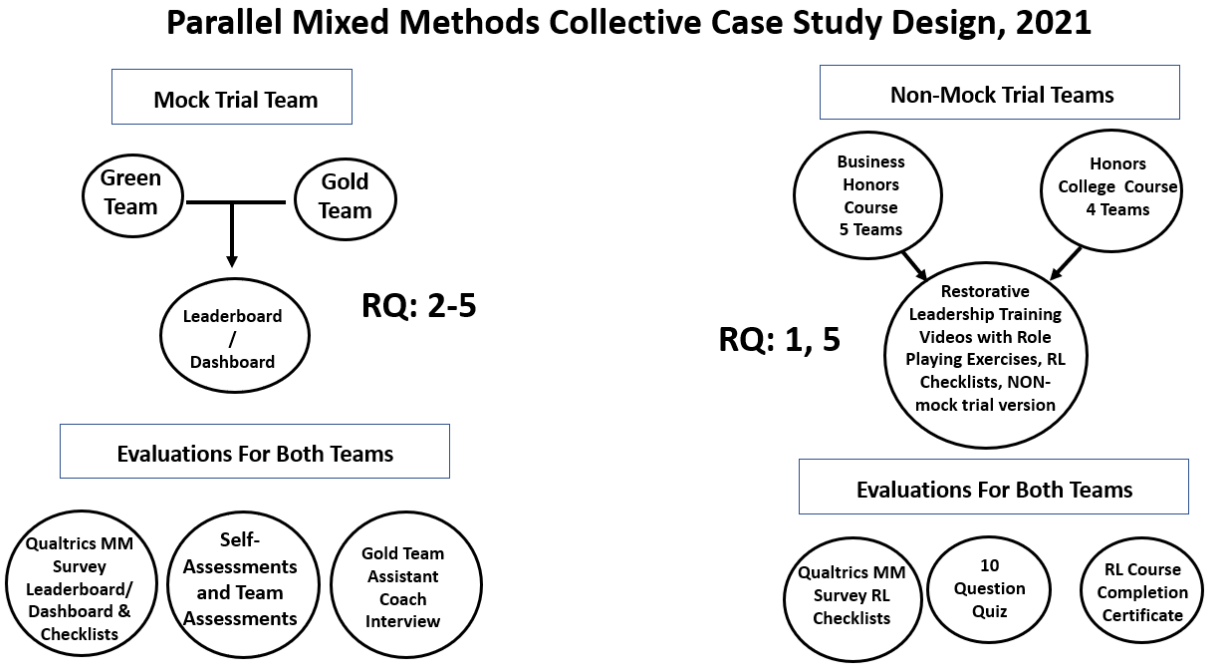
Participants from the honors courses were to watch four Restorative Leadership instructional videos. Each video defined, described, and created a common language for each of the four tenents mentioned above. After watching the video, students engaged in roleplays during the class, where there are at least one to two observers on pre-established teams (in some cases, the whole team). After the roleplay, everyone was to complete either the self-assessment checklist on a Google Form or the Observer's Checklist on a Google Form. Then a debrief was conducted regarding the participants' experiences. This cycle occurred at least once more, where students who roleplayed now become observers and vice-versa.

A leaderboard (dashboard) was created for the mock trial team for both Gold and Green team participants to see their standing as individuals and as teams. These dashboards were used to form the team that competed in collegiate competitions. The seven top performers, according to the dashboard, were selected. Points were earned based on individual performance in various roles during mock trial practices, learning materials, and appropriate application of the mock trial rules. Individuals and teams also earned points for demonstrating Restorative Leadership skills during mock trial training drills and practices.

2.3 Data Collection. The American Mock Trial Association judging form (AMTA, 2019) was adapted into a Restorative Leadership assessment tool. This tool is developed into both a self-assessment checklist and an observer checklist. The self-assessment checklist included 14 behavior questions with a scale ranging from 0 (“Fails to Practice Skill”) to 8 (“Practices Skill and Encourages Others to”). During the semester, as part of the assigned course work, both honor’s courses completed the Restorative Leadership training videos, were required to provide a certificate of completion, and took a 10-question quiz about the materials. In addition to this, each participant was asked to complete a self-assessment checklist to assess their performance of the Restorative Leadership skills after engaging in a roleplay activity. The observer checklist included 14 questions with the same scales, and after roleplays where the participants were observers, they were asked to complete the observer checklist. Two focus groups were conducted with the mock trial’s Green and Gold Team members. The focus groups were designed to ask participants’ experiences and reflections on the use of gamified team strategy.

3. Results.

Figure 1
Design Model



Research Question 1. *How effective was the restorative leadership training in helping participants apply the skills in application exercises?* This question was to assess participants performance applying restorative leadership skills after receiving restorative leadership training. The noncompetitive teams, 47 of the 48 participants completed the individual quiz. The range was 5-10, the average was 7.85, and the standard deviation was 1.54. Over 76% scored above a seven, and about 30% scored nine or higher on this quiz. These results indicate that students could recall 50% or more of the key concepts from the Restorative Leadership videos. Of the 48 students required to complete the training, 47 students participated in all or most of the activities, 23 were required to submit a certificate of completion as part of the module requirements (honor's college course). This certificate was only obtained after they completed quizzes built into the training. 19 of these 23 submitted a certificate. In the business honor's course, 24 of the 25 who participated earned the certificate. To receive a certificate, participants had to score higher than 80%.

Research questions 2-4 were specific to the competitive teams because they addressed the influence of the gamified team strategy, a leaderboard/dashboard, on participants' performance and preparedness both individually and as a team. Quantitatively this was to be assessed by the mock trial restorative checklists and an anonymous mixed-methods Qualtrics survey. These Quantitative results were to be augmented with two focus groups, one with each team. However, only ten mock trial members completed the survey, four Gold Team and six Green Team members. Because this was anonymous, it is also possible that some of these participants also participated in the focus groups.

Research Questions 2. *How did the use of the gamified team strategy impact participants' individual performance*? This question was specific to the competitive teams to see how the gamified strategy impacted their individual performances. Though there were only ten members, the results showed that 90% paid some attention to the dashboard (yes, somewhat, no), and only one member did not Mean = 4.70, *SD* = .64. On a 5-point scale (strongly agree to strongly disagree), 70% of the participants felt that the dashboard somewhat too strongly influenced their individual performance, Mean = 2.30, *SD* = .78. When exploring how the dashboard influenced their individual preparedness, the participants reported the dashboard somewhat to strongly influenced their preparedness, Mean = 2.20, *SD* = .76.

Research Question 3. *How did the use of the gamified team strategy impact team performance?* This question was specific to the competitive teams to see how the gamified strategy impacted their team's performances**.** When asked to assess the influence of the leaderboard on team performance, there was more of a divide. 40% somewhat agreed, 20% remained neutral, and 40% somewhat disagreed, Mean = 3.00, *SD* = .89. The results for how the leaderboard influenced the team's preparedness were varied, 40% strongly or somewhat agreed, where 40% somewhat or strongly disagreed again 20% remained neutral, Mean = 3.00, *SD* = 1.18.

Research Question 4. *How did the use of gamified team strategy influence participants' preparedness for class?* This question was specific to the competitive teams to see how the gamified strategy impacted their individual preparedness for class. When exploring how the dashboard influenced their individual preparedness, the participants reported the dashboard somewhat to strongly influenced their preparedness, Mean = 2.20, *SD* = .76.

Research Question 5. *How did the dual assessments impact participants' performance?* This question was to assess participants perceptions and use of the restorative leadership checklists. At least 38 participants responded to portions of both checklists. The responses were not identical for both the self-assessment checklist and the observer checklist. Of the 38 participants who completed the self-assessment checklist, 37, or over 97%, stated they understood what was being asked of them, 20, and understood their response options, 17. For the observer checklist, 21 of the participants, just over 55%, said they understood what they were being asked, 15, over 39% said they understood their response options, one participant, 2.6%, said they did not know what they were being asked. One participant marked other, 2.6%. When examining the checklists, there is a difference between the self-assessments and the observation checklists. See Figure 2 for a comparison between two checklists.

Qualitative Results for Research Question 5. The decision not to run any statistical tests was made because of the qualitative feedback from the mixed methods Qualtrics survey. A common theme that emerged from participants regarding the self-assessment was changing the formatting, reordering the questions, putting an N/A option, or including open-ended questions. However, just as many responses stated that no changes were needed, it was clear and concise. When asked what reason participants would recommend, or not, recommend the self-assessment for assessing leadership skills, the predominant theme was that participants would recommend this assessment because it helped participants reflect on their actions, "I would recommend the self-assessment because it allows one to reflect and become aware of one's past actions in order to make improvements."

Another theme that emerged was how this tool provided a way for participants to be a better leader, as noted by the following two quotes. “I think the self-assessment overall is a good tool because not only does it remind you of the leadership skills, but it also provides a checklist of actions that you can evaluate yourself on and maybe encourage you to do better in the future." And “I would recommend simply because I have learned so much from it of how to be a better leader, get out of my comfort zone when it came to talking about personal problems from the past, and just be more supportive others throughout this process.”

The Observer Checklist had contradictory themes and seemed to cause participants confusion. Based on responses, it appeared that instructions were not clear on how to use the Observer Checklist. Participants were not sure if they were to focus on each individual in the role play or the overall efforts or objectives of the exercise. Some participants felt that the identified skills did not go with the activity they were observing, “I felt like some of the questions did not apply to the situation, so I was confused on how to respond. Also, clearer instructions would have helped to know how to answer the question." Of the 21 responses to what participants would change, 13 stated "NA," which indicated that they had read the question and had no comments about changes. One participant recommended that we have a comments section about what observers enjoyed about the activity they were observing.

When the participants were asked if they would or would not recommend the Observers’ Checklist, like the self-assessment, the common theme was yes. Participants felt that this assessment enabled them to “properly” assess the players in the role play. Others found it to be helpful in a social learning context, “I would recommend this survey because by reflecting on what others did well and what they could have improved upon, you can improve your own approach. You may see some similarities between yourself and others and decide that didn't work out for them, so I'm not going to do it either." Of the 21 responses, two participants stated "NA," again indicating they had read the question, one person said, “I did not use it but they people on my team that did helped us see what we did not,” and one person said they were not sure if they would recommend it because they feel an open-ended assessment would be more “valuable way of reflecting.”

Figure 2

Noncompetitive Team Restorative Leadership Checklists Comparisons

Restorative Leadership Skill		0 Fails to practice	2 Attempts/ Fails	4 Attempts/ Occasional Succeeds	6 Usually Practices/But Occasionally Stops	8 Practices Skill and Encourages Others To
Invite others to participate	Self			3	18	20
	Observer		1	2	10	24
Affirm others	Self		1	4	12	24
	Observer			5	14	18
Respectfully listened to other's	Self			1	11	39
	Observer			2	7	28
Encouraged others	Self		2	7	17	15
	Observer		1	3	14	19
No gloat when I win	Self	1		5	9	26
	Observer			3	8	26
Recognize others' efforts	Self		1	3	16	21
	Observer			2	7	23
Provided others with support	Self		2	6	13	20
	Observer			7	11	19
Demonstrated courage by not giving up	Self	1		6	15	19
	Observer			3	14	20
Summarized others' point of view	Self	1	3	5	15	17
	Observer		1	6	11	19
Restored relationship after conflict	Self		4	4	14	19
	Observer		3	6	11	17
Used "yes and" statements in my responses	Self		3	10	6	16
	Observer		2	12	10	13
Critically assessed the weaknesses of arguments	Self		1	8	15	17
	Observer			8	15	13
Critically assessed the strengths of arguments	Self		2	3	20	16
	Observer	1		4	12	20
Critiqued authority	Self		2	12	15	11
	Observer	1	2	5	16	13

Note. The cells are split for ease of comparisons between self-assessments on the Restorative Leadership skills and observers' assessments of applied Restorative Leadership skills during roleplays. The number reflects the number of participants that marked those specific ratings.

Qualitative Results, Focus Groups. Though a focus group for the noncompetitive team did not occur, the individual interview supported the theme of confusion regarding instructions. The participant did make it clear that she enjoyed learning about Restorative Leadership. However, when asked if her team was using restorative skills, she stated that the team was not using them in their interactions. Then later, she stated that the restorative leadership training was helping the team understand the different ways they communicated.

A major issue was discovered too late in the study. The program director and coach of the Green Team did not administer the Mock Trial Restorative Checklists as the teams' dual assessments. He created his own assessment. Based on the low number of participants and the feedback from the focus groups, these assessments were found to be confusing as time went on during the semester, and members from each focus group stated that they were confusing and did not help performance or preparation. The following two quotes exemplify what was reported in both the survey and the focus groups: “I don't think that I saw any changes after the implementation of the assessments. I think most of the team side as a chore and they were confused 90% of the time that they were filling it out, and the only feedback I could give reach out to the Professor [blank]or try your best because,” and “I don't know if they necessarily help because, like a lot of us just ended up working with people that we already kind of knew how they worked in a sense, and so like. It was definitely a….. I guess a little weird like kind of going in and like sometimes I felt like seeing the assessment question did like apply, but also didn't apply and so.”

These quantitative findings are supported by what was discussed in both focus groups. The results were mixed. However, there was a definite difference between the Gold Team and Green Team themes. The Gold Team's introduction to the leaderboard caused the team confusion, but they also felt it was mismanaged and not transparent. It caused them to focus on their individual performance at the cost of team cohesion. Two participants stated, "I was worried that they would then come in and take a spot, and then they would take away the team chemistry and it wouldn't work as well, and not - not even mentioned the fact they would also have to learn the material and a much more quick rate and may not be able to catch up as fast.” And, “You know, but instead we were kind of focused on kind of our own individual things that we had to do so that we could just get on the team to begin with, with you know what felt like kind of an arbitrary leaderboard system. So, it definitely kind of forced us to working on our own when we should have been working together.” The Gold Team’s coach’s comments also indicated this dual result, “the gamification piece was helpful in the in the way that it incentivizes them to work harder. And it pushed them it basically gave them a reason to kind of go further than what they go beyond what they use what.”

When asked what surprised the Gold Team participants the most, one of the focus group participants stated, “What surprised me most was how much better prepared, we were this year for the competition, we were last year um it was it seemed like we were much more. We had a much better grasp of the material; we knew what we were doing a lot more.” Overall, the themes for both the assistant coach and Gold Team members reflect how the leaderboard did impact their individual performance and helped their preparedness. However, initially, it was at the cost of the team cohesion, or what this focus group called team "dynamics."

On the other hand, the Green Team felt that the leaderboard helped provide them feedback on their performance and what they needed to earn points and be better prepared. They also mentioned how Canvas impacted their preparation. This latter theme was labeled under "other" in the Tools to Impact Performance theme. This is because a key difference between the Gold and Green teams' is that the Gold Team is voluntary, and the Green Team comes from a mock trial course that students are getting course credit for.

The results from both the quantitative portion of this study and the qualitative indicate that the Restorative Leadership training helped help participants recall and apply restorative skills during their quizzes for the certificate and the 10-question quiz given in the class as part of their Restorative Leadership Module. In addition to the quizzes, the mixed methods survey regarding the checklists overwhelmingly said these checklists helped evaluate and apply their skills, despite some confusion regarding labeling of skills and instructions for the observer checklists.
The quantitative and the qualitative data indicate that the leaderboard did influence both performance and preparedness, individually more than the team. It appears that the Green Team benefited positively from having the leaderboard, both as feedback on their performance and as guidance on what to do. For the Gold Team, they felt that the leaderboard harmed their team dynamics initially. As time went on, they felt that it could be a good tool, with more transparency and better management. See Figure 3 for a summary of the outcomes for the research questions.

Figure 3
Research Question-by-Outcome Joint Display

Research Question	**Quantitative Outcome**	**Qualitative Outcome**	**Differences/ Similarity**	**Integrated Statement**
RQ 1 & 5	The numbers seem to support that the training did help the noncompetitive participants apply the restorative leadership skills, as seen with the quiz results, the certificate completion, and the	The qualitative data supports that the checklists help participants recognize and engage in restorative leadership skills. However, there were possible formatting issues on the self-assessment, and the directions and identified skills were confusing on the observation checklist. The majority of the	The differences were that though the checklists and quiz questions may have caused some confusion, participants still felt the checklists helped with applying the Restorative Leadership Skills. The quiz results indicate that the participants understood the	There results from both the quantitative portion of this study and the qualitative indicate that the Restorative Leadership training was supportive in helping participants apply restorative skills. The results, especially the qualitative, indicate a need to address the instructions for the checklists, specifically the Observers Checklist,

	checklist results.	responses recommended no changes or recommended both checklists.	main concepts from the videos.	and how to use the checklists during activities. These results also indicate a need to revise the Observers Checklist for clarity and ensure that these identify skills are observable and measurable.
RQ 2, 3, & 4	The results are mixed on whether the leaderboard impacted individual and team performance and preparedness. It appears that the leaderboard had more influence on individual performance and preparedness than on team performance and preparedness.	Participants' comments in the focus groups, the coach's interview, and the open-ended survey questions also support the mixed results. The main themes here were that participants felt others did not pay attention to the leaderboard, or they only paid some attention to it. While others said it did impact them individually, however many reported as a team, and they felt it did not impact them. Nevertheless, at least one participant said it did help knowing team status as well as individual.	The focus groups had the biggest differences. It was clear that the Gold Team felt that the leaderboard could be effective if it were managed well and how points were earned was more transparent. However, they felt that other things could determine a successful team, such as observing the dynamics of individuals and just plain time and practice, as echoed by the coach. For the Green Team, overall, they found the leaderboard helpful and the points motivation. They also mentioned other factors in their	Based on the overall results, it is clear that there is a need to be clearer on the purpose of the leaderboard, better management and that the leaderboard alone does not help with team preparedness or performance but appears to impact individual preparedness and performance more. There appear to be two emergent themes that should be examined further, the role of motivation and experience on performance and preparedness.

			preparedness, such as Canvas and having the materials to prepare from.	
Emerging themes or ideas for continued research	Use a motivation skill Evaluate experience level with mock trial Be sure to have competitive teams use the checklist Be sure to have trained observers use checklists for both competitive and noncompetitive teams	Address self-assessment about motivation. Run focus groups for noncompetitive teams Determine if identified themes should be used as a priori themes for the next study	NA	It would be good to revise the observer checklist and continue to test both of the checklists as assessments. See how best to begin collecting data for inferential statistics.

4. Discussion. Several issues emerged when recruiting participants for the focus groups, for both the competitive teams and noncompetitive teams. It was clear that the primary researcher needed to be the one who sent all communications to the participants, such as making the requests to participate in the focus groups, completing the Restorative Leadership Checklist assessments, having the Gold Team review the Restorative Leadership instructional videos, and ensuring that the competitive team participants received invites and follow-ups to complete the Qualtrics survey. By not having the primary researcher in charge of the above processes, valuable input was lost from having neutral outside observers use these checklists to evaluate the competitive teams' mock trial skirmishes or competition. This insight would have given the study more data about how to revise the Restorative Leadership Checklists for clarity as well as helping determine how the current revised checklists' reliability and dependability were viewed by an individual who is unbiased and knowledgeable about mock trial processes.

Three interesting themes emerged during the focus groups: the role of motivation, experience vs. nonexperience, and how the Gold Team felt that the dashboard did little to improve the Green Team's performance as the semester wore on. The program director has begun redesigning the team so that motivation and experience levels might be offset because a mock trial class will no longer be offered. He is determining what the prerequisites will be for joining the mock trial team. He is determined to keep the leaderboard, and hopefully, the results from this study will help him create more clear guidelines and management with the leaderboard.

The significance of this study is that once these instruments prove to be valid and reliable in settings beyond a mock trial course, they can be used to help train a workforce in Restorative Leadership and ensure that employees are transferring the skills to their workplace. The results of this study are promising about the possibility of interdisciplinary application of the Restorative Leadership instructional videos, Restorative Leadership application exercises, the Restorative Leadership checklists as assessments of applied skills, and does warrant more in-depth studying.

4. Limitations and Future Directions

There were many limitations to this study. One major limitation was that convenience sampling was used, which meant that one of the noncompetitive teams was co-taught by the primary researcher, the program director from the mock trial team, and another professor. This could have produced response bias, researcher bias, and some threats to internal validity, such as timing or maturation. Not only is this study subject to these biases and threats, but the sampling process, which was a combination of convenience and purposive, also makes generalizing our results difficult. Because there were unplanned changes to the design that impacted research questions one and five, not to mention the low number of participants for research questions two, three, and four.

These limitations, however, guide numerous directions for future research. After revising the observer checklist, it will be good to test the instructions and ensure that the identified skills are observable. Next, the videos should be evaluated using Kirkpatrick's four levels of evaluation (Kirkpatrick, 2006). The researcher will want to evaluate the reaction and learning levels. A mixed-methods survey could help assess if and how the videos helped apply restorative leadership skills. Finally, another area to explore more is how participants are motivated and how they view either the leaderboard and/or the Restorative Leadership training.4. Significance of Research

The significance of this study is that once these instruments prove to be valid and reliable in settings beyond a mock trial course, they can be used to help train a workforce in Restorative Leadership and ensure that employees are transferring the skills to their workplace. The results of this study are promising about the possibility of interdisciplinary application of the Restorative Leadership instructional videos, Restorative Leadership application exercises, the Restorative Leadership checklists as assessments of applied skills, and does warrant more in-depth studying.

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How Department Culture Influences Innovation in Online Teaching for "Pandemic Laggards"

Faye S. Furutomo
Learning Design and Technology, University of Hawai'i at Mānoa
ffurutom@hawaii.edu

Introduction

Institutions of Higher Education (IHEs) are focusing on online programs as a way to innovate (Magda & Buban, 2018), but faculty buy-in is a major barrier (Walker et al., 2018). Due to the COVID-19 pandemic in Spring 2020, many higher education faculty were forced to teach online for the first time (Means & Neisler, 2020). Rogers' (2003) Diffusion of Innovations (DOI) theory suggests that the adoption of an innovation, such as online teaching, takes place over time, and the last group to adopt are known as laggards. They adopt an innovation often when there is no other choice. In this study, the term "pandemic laggards" will be used to describe faculty who started online teaching due to the pandemic.

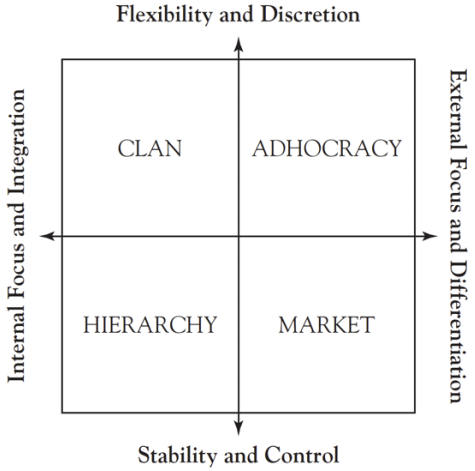
Individuals undergo a process in deciding to adopt (or not adopt) an innovation, which is influenced by multiple factors (Rogers, 2003). However, two factors are particularly relevant to this study. The first, "re-invention" is changing or modifying an innovation in the process of implementing it (Rogers, 2003). Higher degrees of reinvention tend to speed adoption and lead to longer use (Rogers, 2003). The second factor is organizational culture (OC) or the "system of beliefs, values, and behavioral norms that come to be taken for granted" (Schein & Schein, 2016, p. 6). With regard to technology use, aspects of OC have been shown to be influential among faculty (Boichuk & Fast, 2017; Reid, 2017) and in implementing online (Zhu, 2015; Zhu & Engels, 2014) and blended learning (Porter & Graham, 2016).

The pandemic provided an opportunity to explore the relationship between OC and online teaching adoption among a unique group of faculty adopters. The purpose of this sequential explanatory mixed methods study was to explore how pandemic laggards' willingness to adopt new online teaching strategies were related to their views of their departmental culture.

Conceptual Framework

The conceptual framework for this study combined Rogers' (2003) DOI to categorize faculty adopters, and Cameron and Quinn's (2006) Competing Values Framework (CVF) to describe OC. The CVF and its diagnostic component, the Organizational Culture Assessment Instrument (OCAI), was designed to capture participants' views of their current and desired culture into one of four culture orientations (Figure 1): clan, adhocracy, market and hierarchy (Cameron & Quinn, 2006). The OCAI is organized in six dimensions: Dominant Characteristics, Organizational Leadership, Management of Employees, Organizational Glue, Strategic Emphases and Criteria for Success.

Figure 1
Competing Values Framework



Note. Reprinted from *Diagnosing and Changing Organizational Culture* (p. 35), by K. Cameron and R. Quinn, 2006. Jossey-Bass. 2006 by John Wiley & Sons, Inc.

Clan organizations engender loyalty through shared values, consensus decision making, and practices that empower employees (Cameron & Quinn, 2006). Hierarchy organizations foster stability and efficiency and value clear lines of leadership, standardization of processes, and employee accountability (Cameron & Quinn, 2006). Organizations with a Market culture focus on the external environment, with the constant goal of gaining a competitive advantage (Cameron & Quinn, 2006). Adhocracy organizations have a decentralized structure that values individuality, experimentation and future-oriented thinking (Cameron & Quinn, 2006).

Context & Design

This study took place in Spring 2021 at a flagship campus of a large public research university, which typically offers approximately 500 courses via distance education per semester. In Spring 2020 prior to the pandemic, about 15% of courses were taught via distance. In Fall 2020, 81.6% of courses were taught online, 12.9% were hybrid (combination of in-person and online) and just 5.5% were face-to-face (Bruno, 2020).

Email surveys were sent in February 2021 to faculty who taught online that semester (n=1281), which asked about participants' online teaching background and departmental culture based on the OCAI. Of the 184 usable responses, 61% of faculty (n=113) reported being new to teaching online due to the pandemic.

Additional data were collected via seven follow-up interviews with selected survey respondents who identified themselves as new to teaching online due to the pandemic, and who characterized their department with varying OC orientations. Interviews were analyzed using thematic coding (Ary et al., 2019) to obtain codes, categories, and final themes.

Results

Quantitative

The quantitative portion of this study sought to answer, what is the relationship between pandemic laggards' current and desired OC and their plan to teach online once the pandemic is over?

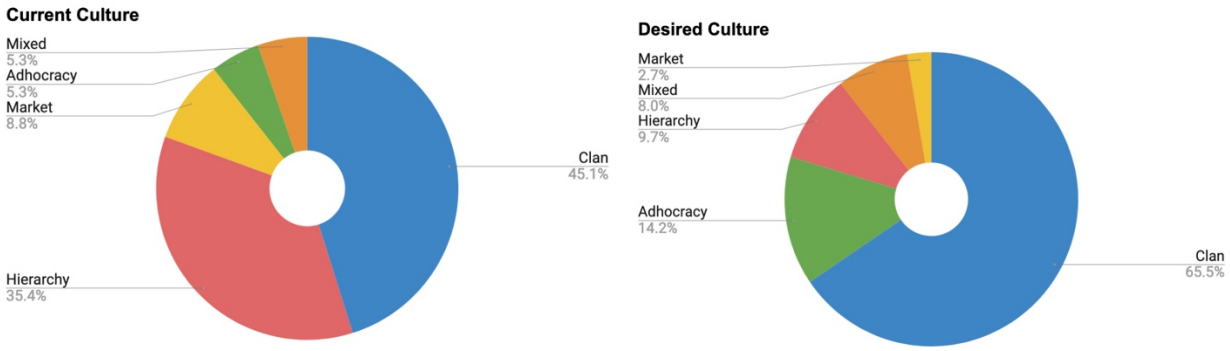
Current & Desired Cultures

Of the 113 self-identified pandemic laggards, 45% (n=51) described their current departmental culture as a Clan type, 35% (n=40) as Hierarchy, 9% (n=10) as Market type and 5% (n=6) as an Adhocracy. In addition, 5% (n=6) described their culture as a mixture of multiple types with four of those describing their OC as a mixture of Clan and Hierarchy.

As for participants' desired culture, 66% (n=74) desired a Clan culture, 14% (n=16) an Adhocracy, 10% (n=11) a hierarchy, and 3% (n=3) a market culture (Figure 2). Seven percent (n=9) desired a mixed culture, with eight preferring a mixture that included the clan culture and six including the hierarchy culture.

Figure 2

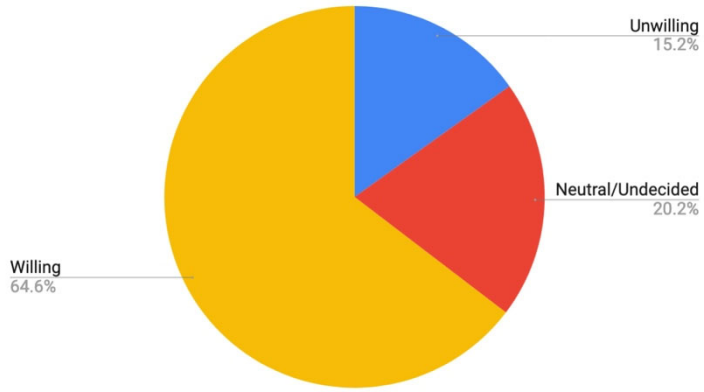
Pandemic Laggards' Current and Desired Cultures



Post-pandemic teaching plans

Of the 104 participants who responded to this question, sixty-two percent were willing to teach online after the pandemic was over (n=64), while 19% (n=20) were undecided or neutral, and 19% (n=20) were unwilling to teach online (Figure 3).

Figure 3
Plans to teach online post-pandemic



No significant relationships were found between participants' current and desired cultures and their plans to teach online post-pandemic. A chi-square test found no significant association between current culture and pandemic online teaching plans X^2 (8, N = 104) = 9.91, p = .271 ando no significant association between desired culture and pandemic online teaching plans X^2 (8, N = 104) = 8.80, p = .360.

Qualitative

The qualitative portion of this study explored how pandemic laggards described the influence their OC had on their willingness to adopt new online teaching strategies and their plans to teach online after the pandemic. Pseudonyms are used for interviewees.

Willingness to adopt new online teaching strategies

There were generally two levels of faculty willingness to adopt new online teaching strategies, 1) transformational and 2) minor modifications. Four interviewees made transformational changes, taking advantage of a number of online tools and/or strategies. Examples of these changes include opting for an asynchronous delivery mode, and creating an online set of modules to accompany a course. Three interviewees only made minor modifications, delivering their courses largely lecture-based using web conferencing tools such as Zoom. These faculty made only minor modifications to how they teach in person. The OCAI's six dimensions were used to organize the emergent themes.

Dominant Characteristics. Dominant characteristics describe the overall characteristics of an organization's culture. The interviewees described their department cultures in different ways, see Table 1. One important theme that emerged was individualistic, as the faculty interviewed were primarily from departments in which collaboration around teaching and research was not the norm. Participants were split when describing their departments with three describing their department's culture in mostly positive terms, and four describing their culture in critical terms or as less than ideal. For the three who were generally positive, they used terms like collegial, supportive and personal. Two out of three were from clan cultures, and all three chose clan as their desired culture. For the four who were critical, they used terms like inefficient, dysfunctional or transitional, and three out of four desired cultures that were different from their current culture.

Table 1
Interviewees' cultures

Interviewee	Positive or Critical	Current Culture	Desired Culture	Descriptors of Culture
Beau	Positive	Hierarchy	Clan	Individual with shared decision making
Nathan	Positive	Clan	Clan	Performance focus, mixed personal connection
Cory	Positive	Clan	Clan	Collegial and supportive
Patricia	Critical	Market	Clan	Supportive leadership, but stressful due to many changes
Fiona	Critical	Hierarchy	Adhocracy	Dysfunctional, conflicting personalities and values
Ethan	Critical	Clan	Adhocracy	Inefficient, Culture of Poverty
Martin	Critical	Hierarchy	Hierarchy	Highly individual, divided by personal agendas

Leadership Style. Leadership style is the approach to leadership within the department. In this area, two themes emerged. The first theme was that of responsive leadership, particularly in regard to instructional issues. Examples of positive or responsive leadership included providing teaching and learning assistants to help faculty with the increased workload, advocating to unit or campus-level administration about instructional needs, emotional support when faculty came to them with issues, and providing online teaching resources such as training or materials. Examples of negative leadership included being too closely aligned with administration-level politics or being too focused on short-term financial gain versus capacity building, both seen as detrimental to an increase in online teaching with one interviewee stating, "Well, I mean given that there's really... a culture of not having any extra resources or ability or investment in pedagogy, that doesn't really make me want to try out a lot of stuff."

Another theme that emerged was faculty autonomy. Most interviewees described their department's leadership as fairly hands off in terms of how faculty taught their courses. According to a number of interviewees, a high degree of faculty autonomy contributed to their willingness to try new online teaching strategies, as they felt free to make changes according to their preferences or student needs. One interviewee mentioned that prior to the pandemic her course enrollments were closely scrutinized and her courses often closed due to low student numbers. During the pandemic, she noticed less oversight, which contributed to her feeling more freedom to implement new online teaching strategies. Some interviewees mentioned that because of a high degree of autonomy, they did not think culture impacted their willingness to adopt new online teaching strategies.

Management of Faculty and Staff. This dimension encompasses how employees are treated and looks at the working environment. In this dimension, two themes emerged. The first is efficient administrative support. Several interviewees expressed being stretched thin during the pandemic, impacted by both a pandemic hiring freeze and increased demands of pivoting to online learning. One faculty member mentioned that it took weeks to handle simple purchasing with grant funds, inefficiencies that took up time that could have been spent on teaching practices.

The second theme was targeted instructional support. Several interviewees mentioned utilizing campus or unit-level support in their transition to online teaching. However, existing services did not meet all interviewees' needs. One interviewee desired personal support saying, "I didn't have the time or the energy to explore all the technical possibilities and exchange five letters with ITS [campus IT services]. If there was somebody here... it would help." In addition, there were particular issues faced by interviewees who taught large classes, such as giving exams, grading and preventing cheating. Two interviewees mentioned the importance of discipline-specific online teaching support. Beyond technical or instructional support, two interviewees mentioned other practical needs. One lacked a proper space at home to conduct Zoom sessions, and another interviewee was not able to be reimbursed for teaching software due to campus rules on reimbursements.

Organizational Glue. Organizational glue is what bonds an organization together. In this area, three themes emerged. The first was students, as stated by one interviewee, "Organizational glue that binds our department together, really that's our students because everyone cares about our students quite a lot." All interviewees talked about how students' feedback and course outcomes influenced their practices.

The second theme was peer support. Two interviewees spoke about influential peers in their departments who served as a hub for online teaching and resources or helped other faculty. Another interviewee shared that she herself provided peer support, giving demos on using Zoom and sharing with her colleagues a list of online teaching resources she had collected. She desired for peer support to become an established norm, stating, "I think, ideally, it would be nice...if we need something from each other, I feel comfortable picking up the phone or shooting you an email, you should feel the same way."

The third theme was collaboration. As mentioned, the interviewees primarily came from individualistic departments, but faculty described ways collaboration could influence their online teaching practices. Several interviewees pointed out that they felt more disconnected from fellow faculty due to social distancing. Co-teaching was a potential form of collaboration mentioned with excitement by one interviewee who stated, "That could work if we have somebody that's taught the course once and then they're bringing on additional people to help bring them up to speed using tools, but then also to bring in new ideas." Collaboration also had the potential to negatively impact efficiency according to one interviewee who stated, "It makes no sense to coordinate with anybody else, that's only extra work in terms of the teaching."

Strategic Emphasis. Strategic emphases are areas of emphasis that direct the department's strategy. In this area, one major theme emerged, the alignment to shared values and goals. One important shared value among all of the interviewees was student success. Other shared values and goals discussed were that of staying accredited, serving students in a culturally appropriate manner, reaching underserved communities and raising funds. Some interviewees discussed that an important shared value was to do what is best for the group or department over the individual. One interviewee mentioned that during the pandemic, he had been willing to take on additional class sections to benefit the department.

Criteria of Success. Criteria of success is how success is defined and what gets rewarded and celebrated in the department. Two themes emerged in this area. The first was research, and the fact that it often is considered more important than teaching in faculty evaluation processes. Research was also discussed in terms of the amount of time it takes to apply for grants, publish in journals and supervise graduate students.

The next theme was departmental survival. Some interviewees described their departments as struggling due to financial strains or external pressures. In light of these issues, anything that promoted departmental survival was to be celebrated. One interviewee said, "Definitely student retention gets rewarded, and really anything positive that can put a positive light on our department."

Post-pandemic plans to teach online

Regarding plans to teach online post-pandemic, there were two main themes.

Face-to-face is primary. First was that face-to-face teaching should remain the primary delivery mode, but could include online elements. All interviewees wanted to move back to face-to-face teaching, however, six out of seven wanted to retain some online elements. Interviewees felt their asynchronous teaching materials such as online learning modules and discussion boards offered greater efficiency and could be reused in their courses post-pandemic. Three interviewees mentioned wanting to teach in the future using hybrid delivery methods, with a mixture of online and face-to-face sessions, or "Here-or-there" sessions in which students have the option to attend face-to-face or online. Two interviewees were strongly considering keeping some of their courses online, despite wanting to move back to face-to-face delivery. Having gone through the experience of teaching online due to a crisis, all faculty expressed willingness to teach online again if absolutely necessary.

While there was openness to hybrid online delivery among the faculty, most of the departments represented in this study did not have plans in place to offer new online courses or programs long term. One interviewee shared that his department was open to online courses and programs as a way to support more students, but the department needed help with developing guidelines, expectations and procedures. One interviewee shared that once his department decided to move to all online classes, faculty worked independently thereafter and never reconvened to discuss strategies or outcomes.

Lessons learned. The second theme was lessons learned. Some of the interviewees were surprised by the effectiveness of online teaching. One interviewee remarked that in his asynchronous class discussions, he saw a greater depth of discussion than in any of his classes prior. Another interviewee experienced remarkable improvement in her students using the flipped classroom model, "My students are speaking, they're speaking the target language, like it's phenomenal...I have not seen this kind of progress."

Many of these "pandemic laggards" were also feeling more confident in their online teaching. One interviewee described it this way, "...having spent the time learning more about this in a crisis situation, you know, now I know a lot more...I could apply that in a much more intentional way." Interviewees described multiple strategies they had used to address online teaching obstacles. For example, one interviewee shared that to address challenges of time management and increased enrollments, he implemented a series of short papers throughout the semester as opposed to one large term paper he previously assigned. Others focused on student differentiation strategies that could be employed online to address differing student needs, for example, employing Universal Design for Learning principles. Faculty also learned overall lessons about teaching that can apply in all situations. One interviewee described it this way, "...I've again, taught for 15 years, and I've learned more about teaching in this past year, then maybe most of the years prior."

Discussion

This study explored pandemic laggards' adoption of online teaching at one institution through the lens of OC. The majority of respondents described their departments as a clan culture and many also preferred this culture. This is consistent with findings from other higher education institutions (Obendhain & Johnson, 2004) which also tended toward clan culture. Perception of culture (culture orientations) did not have a statistically significant relationship to willingness to teach online post-pandemic. Due to social distancing related to COVID-19, faculty expressed feeling more disconnected from their peers and not aware of what each other were doing. Because OC is a shared phenomenon (Groysberg et al., 2018), it may have had less influence due to the effects of the pandemic.

Among the seven interviewees' culture orientations, there did not appear to be a clear relationship between current and desired cultures and levels of re-invention or modification of courses. Two interviewees believed their culture did not influence their online teaching practices due to the autonomy faculty have in their departments. This may suggest that in terms of online teaching adoption in higher education, that individual differences are more influential than departmental culture. This would align with the finding that individual innovativeness, or the desire to try new things, has been shown to be related to acceptance of instructional technology (Akgün, 2017). Some transformational faculty, those who made major modifications to their courses, were indeed more willing to try new things in terms of their teaching. Another individual difference possibly influencing the results is help seeking, particularly the willingness to engage in professional development activities such as training or peer support. Daumiller et al. (2021) found that faculty who were motivated by gaining personal competence, had a more positive attitude to the shift to pandemic-related online teaching.

The qualitative data, however, showed that aspects of culture also influenced willingness to adopt new online teaching strategies and willingness to teach online post-pandemic. While faculty were typically autonomous in how and what they taught, there were cultural factors of departments that influenced their teaching practices. Faculty were extremely busy during the pandemic (Giovannella & Passarelli, 2020), and factors that promoted efficiencies such as responsive leadership, and administrative, technical and peer support had an impact. Faculty also cared deeply about their students' success and were willing to integrate new strategies that supported student success. Because a primary evaluation criteria for many of the faculty in this study was research, the time and resources they were able to devote to teaching was limited. These findings highlight a critical discrepancy between faculty evaluation criteria and institutional goals to grow online offerings and support instructional approaches that increase student success. Reid (2014) also identified rewards and incentives as a barrier to faculty adoption of instructional technologies. Addressing this discrepancy may be key to long term adoption of online teaching. Faculty are often willing to start new initiatives, but IHEs cannot sustain the effort without aligning the desired activity to reward systems (Farmer, 1999).

Hodges et. al, (2020) assert that in Spring 2020 when the pandemic began, faculty were engaged in "emergency remote teaching," characterized by less time for planning and quality assurance, and teaching with a one-size-fits-all approach. Means and Neisler (2020) projected by Fall 2020, with the proper supports in place, faculty would move toward optimal online teaching, which is characterized by effective planning, use of a developed instructional design process, integration of community and engagement, more time and support for quality assurance, and ensuring equity and personalization. This study found that some faculty new to teaching online

have begun to make the transition to optimal online teaching. While many felt stressed during the onset of the pandemic, several have integrated community, engagement and personalization and look forward to more time for planning. Continuous innovation, or the process of re-invention (Rogers, 2003), did in fact take place for nearly all faculty in this study. Faculty made various levels of modifications in their online courses in response to student needs, and many learned valuable lessons through the process.

While nearly all interviewees wanted to keep teaching online or use elements of online delivery, they were excited to go back to face-to-face teaching. Faculty in a 2019 study expressed similar preferences, with only 9% preferring fully online teaching, and 51% favoring hybrid approaches (Galanek & Gierdowski, 2019). Now that many more faculty have been forced to teach online, these numbers are likely higher. Trialability, or the ability to try a new innovation, is a factor that impacts the rate of adoption (Rogers, 2003).

It is important to note that all the interviewees were willing to teach online if needed, although it was not their preferred mode. The pandemic appears to have taught faculty that despite previous experience, they are capable of teaching online, and could do it again. Because of the experience of teaching online in response to a crisis, faculty appear to feel a sense of duty toward teaching online. This could be a fruitful area of future research. IHEs may experience more faculty buy-in if online teaching supported growth or survival, such as raising funding or increasing student access. Another potential area of future research could focus on the impact of departmental culture on the offering of online programs, versus faculty's individual adoption of online teaching. Interviewees mentioned that within their departments online programs had been discussed but not implemented due in part to cultural influences such as conflicting values between administrators and faculty. Students want to keep taking fully online and hybrid courses post-pandemic (McKenzie, 2021). Now that faculty are open to teaching online or hybrid, it behooves departments to design course offerings that align with student preferences.

Limitations

This study was conducted during the COVID-19 pandemic, therefore results may not be generalizable to other periods. While OC has been shown to have a positive relationship to technology-enhanced and online learning, factors outside of OC frameworks could influence the results (Zhu & Engels, 2014). Also limiting generalizability is that adoption research is often based on self-reporting and reliant on participants' memories (Rogers, 2003). In addition, because this research took place at one institution in a unique geographic and cultural context, results may not be transferable. The researcher is an employee at the institution under study and thus may also be prone to bias.

Conclusion

Higher education innovation experts assert that the lessons learned during the pandemic may lead long term to increased adoption, lowered costs and improvements in online teaching quality (Arum & Stevens, 2020). To take advantage of this transition, Fox et al., (2020) recommends IHEs, "use the momentum of this watershed moment to elevate your approach to online and hybrid instruction" (p. 4). This study has shown that faculty worked hard to transform their online instruction and look forward to making continuous improvements. It also revealed how aspects of OC, a key driver of innovation, can support this process now and into the future.

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Culturally and situationally-appropriate professional development design for principals of ethnic elementary schools in Yunnan Province, PRC

DAI Hongwu,
Assistant Professor of Foreign Languages (on leave), Yunnan Normal University, PRC; PhD candidate, organizational leadership, Eastern University, hongwu.dai@eastern.edu

Dennis Cheek,
Chief Learning Officer, Values Education Pte. Ltd., Singapore, ststoday@gmail.com; Visiting Professor, Innovation and Entrepreneurship, IÉSEG School of Management, France, d.cheek@ieseg.fr

This paper is part of a set of three papers that together consider a complex learning design case emerging in the People's Republic of China. The physical setting for this endeavor is the province of Yunnan in southwestern China, a province of some 48 million persons (Yunnan Government, 2019). Yunnan has the largest and most diverse concentration of ethnic groups in the nation.

We have been engaged in determining a suitable learning design for culturally and situationally-appropriate professional development for principals of elementary schools in Yunnan Province – including incorporating attention to the needs of ethnic minority students. Professional development of these principals is undertaken by Yunnan Normal University – the higher education institution in the Province of Yunnan charged with the task of preparing future teachers and administrators for schools and also for their ongoing professional development. Sitting principals are or will be undergoing a systematic program of professional development in light of recent changes to compulsory education. This program will take about six years to complete across the entire cohort of eligible administrative participants. Our work is intended to influence the topics and approaches of some of this professional development for these practicing elementary principals as well as adaptations for the programs preparing future elementary school administrators and teachers.

A majority (the exact number is presently unknown) of the 10,688 elementary schools in Yunnan are small, rural, ethnic minority-majority schools with 100 or fewer pupils of varying ethnicities and ages (Yunnan Provincial Education Department, 2021). These schools are spread across a geographic area roughly the size of California, two-thirds of which is mountainous and the other third of which lies 1000 feet or more above sea level in high plains and river valleys. Principals of these schools face new and unprecedented challenges requiring rethinking approaches to professional development and support both for themselves and the teachers they lead (Dai and Cheek, 2021).

A New Cultural Analysis Framework

Due to a series of interlocking, complex issues that form the context in which professional development of elementary school principals in the province must occur, we have pioneered application of a new cultural analysis framework we have created tailored to this particular

learning design challenge. The starting point for the framework was inspired by the work of the French *Annales* School of historiography in its attempts to write *histoire totale* – a term that suggests that understanding the human past and present requires tools, techniques, and perspectives that go well beyond the usual historical considerations of people, places, and sociopolitical events placed within a fairly narrow compass of time. Our cultural analysis framework utilizes the following five key components we created inspired by the *Annales* approach: 1) geography & climate factors, 2) history & anthropology factors, 3) economy & society factors, 4) politics & education administration factors, and 5) management styles & learning factors (Dai and Cheek, in press). We believe, as this framework suggests, that the business of teaching and learning is always functioning within much wider contexts of politics, management, economics, society (both anthropologically and sociologically), climate, and geography. Some of these factors change rapidly, while others change quite slowly and almost imperceptibly within normal human perspectives. Yet all of these many factors influence what happens today and what will happen in future days.

Space considerations make it impossible to overview all of these cultural analysis components in this brief paper. Therefore, we have split the discussion of the factors across three papers with factors 1 and 2 discussed mainly in Dai and Cheek (in press), factors 3 and 4 discussed in Dai and Cheek (2021), and factors 4 and 5 discussed here – with factor 4 in this paper adding material not found in the prior papers. We anticipate writing a longer, more comprehensive article, combining substantial attention to all five factors of our cultural analysis framework at a future date when the whole picture is considerably clearer than it is at present.

One important component of our framework is politics and educational administration matters. Here we focus on national education law, the ways in which primary and secondary education is organized in China, and the implications these matters have for the many roles played by principals of elementary schools in Yunnan.

The Organization of Schools in China

China's public education system has been influenced by four factors: 1) ancient cultural heritage and learning traditions (especially Confucian thought), 2) leadership literature from the West, 3) school management theory and practices from the former Soviet Union, and 4) "leadership tenets and principles of the Communist Party of China" (Feng, 2020, p. 3) A four-tiered system of educational administration was enacted by the Education Law of the PRC originally promulgated in 1995 and whose structural features (detailed in Articles 14 and 15) were left unchanged in its 2009 and 2015 revisions. At the top is the national Ministry of Education (MOE) in Beijing. Below the MOE are the 31 Provincial Education Departments (PEDs), or sometimes called Commissions. Below them are the 334 Prefecture-Level-City Education Bureaus (PLCEDs). (A prefecture in China is an administrative unit containing several counties; the large cities within them have their own educational bureaus.) Finally, underneath them are the 2,850 County Education Bureaus or CEBs (Feng, 2020; cf. OECD, 2016).

The MOE sets all national education policies. The PEDs can establish provincial education policies for local variable conditions but they must be congruent with the national education laws and policies. The PLCEDs promote and supervise implementation of the provincial education

policies. Finally, the CEBs handle the day-to-day operational aspects of local primary and lower secondary education. They have the most impact at local levels because they control the funds for the nine years of compulsory education and are also where the 253,736 or so primary and secondary schools get their support, supervision, and evaluation (Feng, 2020). It is important to note that these 250,000+ schools are not the only public schools in China. OECD (2016) reported about 514,000 schools below the university level across China including those in autonomous regions, special administrative regions, and those under other lines of authority within education; attendance in these schools, outside of the first nine years of schooling, are noncompulsory, i.e., the higher grade levels up through the end of high school or vocational school are not required under compulsory education law.

Schools throughout China have similar organizational structures which are standardized by national education law. Leadership within an individual school resides in four key sets of leaders: 1) the School Leadership Team (or School Affairs Committee) – comprised of the Principal (and VPs if applicable), the Party Secretary (and associate secretary if applicable), and the Chairperson of the School Trade Union; 2) Middle Managers are the Directors of the Office of Moral Education, Office for Curriculum and Instruction, and the Office for Scientific Research & Teacher Development as well as Ancillary Services; 3) Lower Managers are the Heads of Grade Units, Heads for Teaching-Study Groups, and Heads of Lesson Preparation Groups; and 4) the Communist Party at the School which is responsible for the work of the School Trade Union, Women's Federation, Communist Youth League (if a secondary school) or the Young Pioneers (if a primary school). Since 2016, the Party representative also leads the moral education of the school and works closely with the school's Director of the Office of Moral Education to ensure that the Party's views are consistently promoted to all people within the school community (Feng, 2020).

These various designated leadership roles are, of course, difficult to both fill and fulfill in small rural schools – a problem not unlike those faced by rural schools around the world (e.g., Kinkley, 2019, for US issues and examples). Too few people wearing too many hats for long periods of time can be a recipe for declining morale and professional burnout. Many supportive resources that are needed in these isolated rural settings are simply not available or if they are made available are difficult to access due to the inevitable constraints of time, technology, lack of knowledge or skills, or competing demands. Rural schools worldwide pose considerable challenges for those responsible for ensuring that education in these schools is consistently of good quality and accessible to all who need it (Kong, Hannum, and Postiglione, 2021). Similar to many other nations with large numbers of very diverse schools, Chinese education policymakers have innovated in a continuing manner to try to address the many challenges faced by school leaders. We now describe a number of recent innovations in approaches to educational administration within the schools of China.

The Principal Responsibility System

A new Principal Responsibility System (PRS) was initially created as part of the 1985 education reforms. For the first time, the principal was made responsible for school development planning. Given its complexities and the need to prepare principals for this extraordinary expansion in their responsibilities, the PRS was phased in over many years as part of a wider overall approach by

the government to improve the nation's schools (Feng, 2020). The PRS is comprised of several pillars. First there is the local education authority (county or district education board) who supervises the principal. The principal is responsible for leadership of local schools, is the legal representative of the school, and under Article 30 of the Education Law is "held responsible for teaching and learning activities and administration" (Feng, 2020, p. 27). (It is for this reason that we are concentrating our efforts on elementary principals as instructional leaders.) Finally, the School Leadership Team chaired by the Principal, is responsible for a wide range of activities including various plans, appointments and removals, annual budget, plans for large expenditures, appraisal of staff, graduation and enrollment policies, major infrastructure projects, etc. A recent change in Party organization at the school level, instituted in 2016, now allows the Principal (if a Party member) to simultaneously hold the positions of both Principal and Party Secretary; a situation which makes the principal the "paramount leader in his/her school." While all of this may sound very "top down" to those unfamiliar with the education system of China, it needs to be noted that across a variety of measures, Chinese schools have been viewed as roughly equally autonomous as local publicly-administered schools in Germany, England, and France (Feng. 2018, 2020).

Since 2001, primary and secondary schools in many regions have successively established school-based management systems that combine government coordination, social participation, and independent school management. During this time period, the Ministry of Education sought to move all schools away from a knowledge transmission model of learning to increased attention on student problem solving, lifelong learning, cooperative learning, and making the curriculum more relevant for local situations and contexts. It also incentivized teachers to move and remain in poor rural areas through special teacher allowances and subsidies for both primary (elementary) and secondary teachers (Kong et al., 2021). These developments have prompted changes in the preparation of principals to be instructional leaders as reflected in both textbooks for aspiring school administrators in China as well as increased research on the roles and responsibilities of principals in serving as instructional leaders (e.g., Wu & Zhou, 2008; Chen, 2010; Walker et al., 2012; and Walker & Qian, 2020).

In order to increase accessibility to education, a key component of China's economic development policies, a 2006 revision of China's compulsory education law (part of Article 2) states that "no tuition of miscellaneous fee may be charged in the implementation of compulsory education." Article 6 further clarified that ". . . the State Council and the local people's governments at the county level and above shall reasonably allocate the educational resources, promote balanced development of compulsory education, improve the conditions of weak schools, take measures to ensure implementation of the compulsory education policy in rural areas and areas inhabited by ethnic minority groups, and guarantee that school-aged children and adolescents from families with financial difficulties and disabled school-aged children and adolescents receive compulsory education." Article 44 further required in the event of family financial inadequacies that ". . . the people's governments at all levels shall provide them with gratis textbooks and give living cost subsidies to boarding students" (Kong, et al.,2021, p. xix).

While these provisions now clearly establish the government's priorities, there are clearly still many barriers that must be overcome throughout the more rural areas of China and elsewhere. One continuing problem, for example, is that children who drop out of compulsory education

generally are not pursued in any systematic and continuous manner by the educational system to return to school and to complete their studies (Wang, Y., 2014; Bilige & Fan, 2020). It is important to acknowledge that dropout problems are in no way unique to China but are a feature of educational systems worldwide (cf. OECD, 2021 for OECD countries and Irwin et al., 2021 for the US). As a consequence, many indicator systems (e.g., OECD) consider schools *fully* enrolled when only 90% or more of the eligible pupils are "enrolled."

Since 2001, Chinese primary and secondary schools have tried many largely ineffective changes in the process of encouraging further development of their schools and deepening their impacts. The main reason for these failures is the lack of systematic thinking among school leaders, especially school principals; e.g., they have faced an ever-increasing set of leadership responsibilities over the past three decades and they may lack ability to think conceptually about the many complex problems that now confront them (Liu, 2013). We suspect that there are a multitude of reasons beyond just the lack of systematic thinking among school leaders, especially in semi-isolated and geographically challenging areas of China such as Yunnan (cf. Wu, 2020).

Five years ago, in an attempt to deepen reforms and improve results of primary and secondary schooling across China, the Organization Department of the CCCPC and the Ministry of Education (2017) promulgated new provisional "measures for the management of leaders of primary and secondary schools." It complemented and further clarified some earlier guidance issued by the Ministry of Education (2013). The provisional measures deal with a series of matters including: 1) entry requirements and professional qualifications for principals and other administrators, 2) rules and procedures for selection, appointment, and service term setting (e.g., serving a maximum of 12 years as a principal in the same school), 3) accountability and performance appraisal, 4) establishment of a career path and motivation system, 5) supervision and restraint mechanisms (to appropriately limit principal's powers), and 6) termination or dismissal mechanisms for school leaders. The promulgation of these rules simultaneously established the primacy of principals and also delineated for the first times the limits of their authority and powers.

Educational Administration Challenges in Yunnan

About eighty percent of Yunnan elementary schools are found in rural areas where 25 formally-recognized ethnic groups are heavily concentrated. These groups move freely across large areas, including both adjacent countries and other regions of China. Schools in these regions are often ethnic minority-majority with 14+ indigenous languages spoken by children and their parents, in addition to parents and children speaking, reading, and writing Mandarin with varying degrees of fluency and proficiency (Chinese Rural Education Development Research Institute, 2017; Dai & Cheek, 2021). Most schools are small (about 100 students) as we have noted, and many are residential Monday-Friday due to sparse and widely dispersed populations across these mountainous regions (Lei & Zhang, 2014). The number of boarding schools is slowly but steadily increasing as authorities continue to systematically decrease the number of total schools due to overall declining numbers and the provision of subsidies for families to board their children at the schools. China's efforts on consolidations appear to be decreasing the dropout rate as well; perhaps larger numbers both increase school activities and provide more opportunities for students to form friendships and inhibit their dropping out (Yu, 2013).Another new

phenomenon are children who remain at school through the weekends and thus board there throughout the school year. Often these are students whose parents are away working in the cities with no local relatives to care for them (Wang, Dong & Mao, 2017). Student populations in the vast rurality of Yunnan tend to vary across the year due to poverty, isolation, hazardous journeys to school, annual migratory patterns, parental need for their free labor, and health (Dai & Cheek, 2021).

The majority of teachers and administrators in these ethnic minority-majority schools are part of the ninety-two percent *Han* culture of the PRC; a group which generally agrees with the view frequently expressed that literacy in China refers to competencies in Mandarin, not in other dialects or languages (Yamada, 2021).There has been mixed success in China with approaches to fully bilingual or trilingual approaches to language learning and use (Tsung, 2009, 2014; Zhang, Y. J., 2013). Valuable programs include plenty of opportunities for immersion in a language, extensive discourse in the language that is related to the school's regular curriculum and highlighting practical uses and applications for the language in question. Many successful programs can be found in cities but in rural areas the many challenges that must be overcome often overwhelm well-intentioned efforts (Tsung, 2009, Sude and Dervin, 2020).

Recent national pronouncements and actions regarding unrest in the borderlands of China will undoubtedly result in changes to government policies regarding local ethnic language learning within the school curriculum and change how schools approach issues of citizenship development and holistic development of children (e.g., Xi, 2014, 2017). The exact nature of these changes is currently unknown.

The need for adaptive leadership has perhaps never been greater. Principals need to be instructional and institutional leaders who can engage in critical thinking about the socio-technical system called formal public education as it faces accelerated change and increasing demands (Blasé et al., 2010; Kinkley, 2019). Principals need to become more culturally attuned to the needs of their teachers, pupils, and communities in areas of the country where the school is vital to community-wide continuity, cohesion, and continuing social and economic development (Cherng et al., 2019; cf. Pasanchay, 2019). Principals need time and opportunity to identify, explore, and question their own beliefs and understandings about the children and families of local ethnic groups. This includes viewing the sociocultural dimensions of students as a resource strength for students' ongoing cognitive, social, emotional, and citizenship development within a holistic frame of reference (cf. Yang et al., 2021). At the same time, principals are responsible within their schools for achieving the government's priority for Mandarin to be the common language ("Putonghua") of the nation (Yamada, 2021).

There is much about our engagement we do not presently know (e.g., Amzat, 2019). Relevant research is meager regarding many relevant issues (Su et al., 2019). There are, however, interesting pointers from ongoing educational and psychological research across an array of fronts including: reducing socioeconomic disparities (Destin, 2020), honing reasoning ability (Bunge & Leib, 2020), improving children's multiple language skills (Hulme et al., 2020), the physical context of child development (Evans, 2021), taking social, emotional, and behavioral skills seriously (Soto et al., 2021), promoting student self-regulation and transfer (McDaniel & Einstein, 2020), addressing discrimination (e.g., Bettache, 2020), understanding

neurodevelopmental effects of childhood adversity (Smith and Pollak, 2021), and providing supportive environments that enhance teachers' self-efficacy (Lackey, 2019).

In addition to socio-technical systems thinking about the educational system as a whole (McWalters & Cheek, 2000), principals also need a formal, flexible, and relationship-focused way to apprehend the need for changes and ways to work through the worldviews, means, methods, and processes that will position their teachers, schools, and communities to successfully respond to emerging challenges. We suspect that Soft Systems Methodology (SSM) will be a useful tool to employ with principals as part of their own professional development and to develop comfort and skills using SSM with teachers and community leaders within their own respective school service areas (Jackson, 2019).

Conclusion

The challenge is to create a working model of how to integrate various factors into a flexible approach that will place principals at the center of a systematic learning and action research program that will produce culturally and situationally appropriate and educationally effective changes to learning on the part of both rural children and the adults who work with them. Success at such a venture will greatly affect the future of these rural children as citizens of the People's Republic of China.

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American Teenagers' Use of Social Media to Learn about College: A Literature Review

Daeun Jung
Florida State University
Instructional Systems & Learning Technologies
1114 W. Call Street, Tallahassee, FL 32306
Email: dj19@my.fsu.edu

Social media can serve as useful learning tools for teenagers. The term social media first emerged in tandem with Tim O'Reilly's declaration of Web 2.0 as a participatory web (Hogan & Melville, 2015). Now, a wide range of online activities with multiple contributors are considered as social media, ranging "from collaborative encyclopedias such as Wikipedia, to social network sites (SNSs) Facebook and Twitter, photo-sharing sites Instagram, and social news site Reddit" (Hogan & Melville, 2015, p. 421). As social media is pervasive in today's teenage life, there are concerns regarding the harmful impacts of social media on teens. However, we, educational technologists, need to proactively find ways to use social media to improve learning and prevent any possible side effects. To fully utilize the new educational opportunities afforded by social media, we should examine the roles of social media in education, as well as the benefits and challenges it presents (Greenhow et al., 2019a, b).

Recent studies found that one of the most common informal learning behaviors among teens on social media is future/college planning (Bagdy et al., 2018; Rutledge et al., 2019). The researchers found that teens use social media to seek out college information by following the institutional accounts of potential colleges as well as by connecting with college students. Given the lack of research on adolescent learning with social media (Greenhow & Lewin, 2016), it is important to synthesize the research to date and figure out the path for the future study.

Thus, this review aims to (a) synthesize the literature on teenagers' use of social media to learn about college and (b) to offer educational practitioners and researchers suggestions for supporting college-bound teenagers. The research questions of the study include:

1. What are some features of previous literature exploring the topic?
2. What social media affordances do teens use to learn about college?
3. What are some obstacles teenagers face while learning about college on social media?

Method

Search and Selection Procedures

I searched the databases ERIC ProQuest, ScienceDirect, and Education Full Text from August 27th to October 7th in 2020 to find the literature. The second search was conducted on August 6th in 2021 to ensure that the recently published studies are included. I consulted with a school librarian to find databases and search terms. The search terms used were (teen OR adolescent OR youth OR "high school student") AND ("college access") AND (online OR internet OR "social media" OR "social network"). I limited the results to be peer reviewed scholarly journals and be written in English. I did not use any specific limit in publication year, considering that social media is a relatively recent phenomenon.

The search yielded a total of 641 articles from the databases. After removing 12 duplicates, I first reviewed the articles' titles based on the inclusion and exclusion criteria,

resulting in 386 articles for further review. The abstract review yielded a total of 96 articles. After reviewing the full text of the articles, I found five that were eligible. Additionally, I looked through the reference lists in the selected articles to find relevant literature. I also utilized Google Scholar's "relevant articles" and "cited by" features to find more recent relevant publications. These searches yielded three more articles, bringing the total to eight.

Selection Criteria

I included the literature examining both teenagers and their learning about college through social media. Only empirical studies published in peer-reviewed journals written in English were considered as eligible literature. I excluded the literature on the use of information and communication technologies in general without providing any data regarding social media. In addition, I excluded the research on college students' social media use for college adjustment. I also excluded studies whose participants' demographic information was not provided in detail. As a result, a total of eight articles met the criteria for inclusion in the literature review.

Results

RQ 1: Study Characteristics

For the eight reviewed studies, I identified some of their key features, including participants, theoretical framework, social media sites examined, and data collected (Table 1).

Table 1
Features of the Literature Reviewed

Study	Framework	Methods, Data Collection, and Sample	Social Media Sites
Brown et al. (2016)	Information literacy	Qualitative Interviews Students from six high schools in Michigan (N = 68)	Not specified; Online in general
Ellison et al., (2014)	Social capital	Qualitative Interviews Students from three high schools in Michigan (N = 43)	Not specified
Marciano (2015)	New media literacy	Qualitative Interviews, focus groups Black and Latina first-gen college applicants from a single high school in New York (N = 10)	Facebook
Marciano (2017)	New media literacy	Qualitative Interviews, focus groups 12th grade Black and Latina first-gen college applicants from a single high school in New York (N = 10)	Not specified
Greenhow & Burton (2011)	Social capital	Mixed methods	Not specified

		Survey: Students from low-income families who were recruited from three urban high schools in the upper Midwest (N = 607) Interviews: Participants selected from those surveyed (N = 11)	
Greenhow & Robelia (2009)	New literacies	Qualitative Interviews, talk-alouds, content analysis of MySpace profiles High school students from low-income families in the upper Midwest (N = 11)	MySpace
Wohn et al. (2013)	Social capital	Quantitative Survey High school students (N = 789) Compared first-gen and non first-gen students	Facebook
Rutledge et al. (2019)	Not specified	Qualitative Survey and activities: High school students from a single high school in Florida (N = 48) Interviews: High school students from the same school (N = 37), Administrators and teachers from the same school (N = 18)	Not specified

Note. First-gen = First-generation

Participants of the Studies

All eight studies reviewed used a sample consisting of high school students. Five studies considered participants' first-generation status by purposefully including them in the samples (Brown et al., 2016; Ellison et al., 2014; Marciano, 2015, 2017; Wohn et al. 2013). Notably, Wohn et al. (2013) compared first-generation students and non first-generation students in terms of social capital and college aspirations. All of the studies except for Rutledge et al. (2019) stated that they included students from low-income households. Regarding the locations of the participating schools, four of the studies sampled participants only from urban high schools (Marciano, 2015, 2017; Greenhow & Burton, 2011; Greenhow & Robelia, 2009); other three studies had participants both from urban and rural areas (Brown et al., 2016; Ellison et al., 2014; Wohn et al., 2013). Marciano (2015, 2017) and Rutledge et al. (2019) recruited students from a single high school in New York and a single high school in Florida, respectively.

Theoretical Frameworks

Three of the reviewed studies adopted the social capital framework to situate their research. Social capital refers to the ability of individuals to access and deploy resources in their social network (Wohn et al., 2013). Ellison et al. (2014) examined teens' online and offline experiences associated with two different forms of social capital: bridging and bonding. They discussed how teens' experiences related to these two types of social capital reshaped their future aspirations. Greenhow and Burton (2011) emphasized the significant role of social capital in

education and psychological well-being. They examined how social media use of high school students from low-income families related to their social capital. Wohn et al. (2013) examined how social capital accrued through parents, peers, and Facebook Friends can affect teens' college application efficacy and expectation of college success.

Four of the reviewed studies adopted the literacy perspective. While they used different terms like information literacy, new literacy, and new media literacy, they all focused on teens' communication practices on social media. Brown et al. (2016) investigated teens' college information seeking practices online to understand what skills and strategies they use to access information about college and how they analyze and evaluate the information found online. Greenhow and Robelia (2009) emphasized the importance of online communication, especially for low-income students, because it allows them to interact with peers based on their specific interests rather than geography. They looked at how teens from low-income families use MySpace from the perspective of new literacy. Marciano (2015, 2017) explored the new media literacy practices of Black and Latina/o youth attending urban public high school.

Research Designs

One study used only quantitative data. Wohn et al. (2013) used questionnaires to inquire about their college aspirations and different types of social capital they had (i.e., demographic, structural, immediate network, extended network). They conducted hierarchical linear regression analyses to identify the added variance due to the inclusion of the four social capital factors.

Six research only relied on qualitative data. Brown et al. (2016) conducted in-depth interviews to examine teens' online practices to learn about college. Ellison et al. (2014) also employed in-depth interviews to investigate how teens' online and offline experiences shaped their understandings of possible life paths. Marciano (2015, 2017) used interviews and focus-group interviews. They adopted a social participatory youth co-researcher approach, in which the researcher recruited focal participants, and the focal participants invited peer participants to the study and performed interviews as coresearchers. Greenhow and Robelia (2009) conducted qualitative case studies to explore teens' novel practices on MySpace by using interviews, talk-alouds, and content analysis of MySpace profiles. Rutledge et al. (2019) used a multilevel exploratory case study. They taught social media lessons to 48 high school students in the first study year and 37 students in the second. Data were collected through survey, audio-records of the lessons, field notes, activity worksheets, and interviews. They also interviewed 17 faculty members and administrators.

One study used both quantitative and qualitative data. Greenhow and Burton (2011) first conducted a survey with high school students from low-income families and used multiple regression analyses to see how intensity of their use of social media could predict their social capital. They selected 11 participants from those surveyed and carried out semi-structured interviews in order to complement the survey data.

Social Media Sites

Two of the studies indicated their focus on teens' use of Facebook (Marciano, 2015; Wohn et al., 2013), and one on MySpace (Greenhow & Robelia, 2009). The other five studies looked at teens' overall use of social media rather than specific social media platforms. Several sites, including Twitter, Xbox, and YouTube, were mentioned by the research participants and were covered in those publications.

RQ 2: Social Media Affordances to Learn About College

The reviewed studies show that teens use social media in various ways to learn about college. I identified the five social media affordances teens use: vicarious experience, information seeking, identity development, emotional sharing, and schoolwork support.

Vicarious Experience

Many of the reviewed literature suggest the promising role of social media in exposing teens to a broader range of people. For instance, Brown et al. (2016) found that teens were monitoring social media profiles of college students at their "dream schools," which informed them about college life and functioned as a motivator. Furthermore, they revealed that teens on social media would inadvertently encounter college-related information from their peers and family members in college. Seeing their college lives shared on social media helped teens make school decisions and inspired them to research more about college.

Information Seeking

Wohn et al. (2013) revealed that having Facebook friends who could give college information and advice was a positive predictor for the first-generation students' expectations about college success. Ellison et al. (2014) reported that a teen who was a member of a special interest Facebook group discussed attending college out of state with the group members. Greenhow and Burton (2011) described a teen encountering a college student going to her interested school on MySpace. The teen exploited the opportunity by inquiring how to get into the school and their personal opinions about the school. Rutledge et al. (2019) also noted that teens networked with college students they encountered on the college's Facebook page and messaged them to ask about school information. Greenhow and Robelia (2009) suggested that first-generation students got advice on their college application by contacting their former classmates. Similarly, Brown et al. (2016) reported that teens used social media to ask college-related questions to their peers and cousins with college experience.

The advanced technological features facilitated disadvantaged teens' information seeking. For example, Marciano (2015) described a teen from an immigrant household who could not afford college tours. Thanks to a friend's suggestion, the teen was able to take a virtual tour through YouTube videos and Facebook pages, which the teen found very beneficial. Moreover, Rutledge et al. (2019) reported that teens were following the colleges' official Instagram, Facebook, and Twitter accounts, where they read the posts and comments and interact with college students. The reviewed studies have also reported teens using the tag and hashtag features to learn about college (Brown et al., 2016; Marciano, 2015). Brown et al. (2016), for example, found that teens utilize hashtags to locate the social media posts about a university's marching band and Historically Black Colleges and Universities.

Identity Development

Some of the reviewed studies show that teens used social media to share their college aspirations and achievements. According to Brown et al. (2016), some teens updated their Facebook status to share their college plans. Friends and family members showed interest in their college application process and gave them encouragement to keep going. Some students posted their admission letters on social media. Similarly, Greenhow and Burton (2011) reported that teens shared their educational plans on MySpace profiles. Sharing their college aspirations and

attainment on social media enabled teens to build and maintain college-going identities and recognize peers who had similar plans. The social support they received reinforced such identity.

Emotional Sharing

Social media became a place where teens vented their stress about college planning. Greenhow and Robelia (2009) found that when teens expressed their concerns about college planning, their former classmates, now in college, gave emotional support by leaving supportive comments on their MySpace accounts.

Schoolwork Support

Marciano (2015, 2017) highlight how teens utilize social media to help one another meet academic requirements for college readiness. They found that teens discussed schoolwork through text messages and Facebook posts. Greenhow and Robelia (2009) and Rutledge et al. (2019) also suggest how teens use social media to support schoolwork, by asking questions about deadlines, organizing study groups, exchanging educational materials, and collaborating on homework. Furthermore, Marciano (2015) described that a teen posted her poem on Facebook that could be possibly used for her college application essay. She tagged a well-known literacy organization in her post, and one of the organization's mentors gave critical feedback on her writing. The teen purposely utilized the tag function to attract the organization's attention and was successful in gaining comments to improve her work.

RQ 3: Obstacles Teens Face While Learning About College on Social Media

Despite the advantages of social media identified above, the reviewed studies have also noted some obstacles that teenagers could face while using social media to learn about college. In this section, four major challenges will be discussed.

Difficulties with Applying Broad Information to Their Specific Contexts

Brown et al. (2016) revealed that while teens reported being able to identify and access college information online, they struggled to evaluate and apply the information to their specific needs. The participants described a large amount of information on the web as overwhelming due to its lack of meaningful context. The researchers thus emphasize the importance of knowledgeable translators who can help them understand the information found online. The term "knowledgeable translator" is defined as "social contacts that students access(ed), via online and offline channels, in order to make sense of generic information and apply it to their specific informational need" (Brown et al., 2016, p.110). The researchers also discovered that a few participants considered social media as an unreliable source of information and preferred authoritative sources such as guidance counselors. However, at the same time, social media may help teens make sense of complex information. For instance, some participants described how a guidance counselor at their school curated information for a Facebook group by filtering information relevant to students. The counselor also answered students' questions about online information and directed them to additional resources. Teens also reached out to peers and family members who were current undergraduates or college graduates, to contextualize information about college. In sum, while teens may have difficulty interpreting information obtained on social media, it could also be a place for them to find knowledgeable translators.

Potential Negative Influences of Social Media

Wohn et al. (2013) revealed in their quantitative research that teens' frequent use of Facebook was negatively related to their expectations of college success. This result implies that not all activities on social media might be beneficial for teens' college aspirations. Moreover, Wohn et al.'s (2013) found that for non-first generation students, the number of Facebook friends were negatively related to their college application efficacy. For first-generation students, the emotional support from Facebook friends was a negative predictor for their college application efficacy. Though the study does not provide further evidence to clarify such relationships, the findings indicate that Facebook friends and their emotional support might have negative impact on college application efficacy.

The Nature of Social Media Platforms That May Limit Network Expansions

Social media platform's distinctive features could affect teens' learning about college. For instance, Ellison et al. (2014) found that on Facebook, teens tend to friend their schoolmates and family members rather than reshaping their networks. The participants mentioned the "normative pressure to indiscriminately friend schoolmates" (p. 526) on Facebook. Such a norm had teens have little control over their friending decisions and thus kept them from being exposed to various worldviews or novel information.

However, the same culture on Facebook where teens network with their existing relationships appears to be beneficial in terms of getting social help. Specifically, Marciano (2015, 2017) found that when teens post questions about school assignments on Facebook, they were able to get quick, multiple answers from their peers enrolled in the same classes. Greenhow and Robelia (2009) and Greenhow and Burton (2011) also found similar results on MySpace, where teens asked for help with their school tasks and received needed help.

Discussion

RQ 1: Study Characteristics and Suggestions for Future Research

All the reviewed studies recruited high school students as participants, and the majority of them considered the participants' socioeconomic backgrounds. They used literacy and social capital as their primary frameworks to explore the topic. Empirical studies based on a broader range of theoretical frameworks may help us to see teens' social media use from diverse angles and thus enrich the research conversation on this topic. Potential frameworks that could be employed include communities of practice, self-efficacy, affinity spaces, cultural historical activity theory, and self-regulated learning theory (Greenhow et al., 2019b). In terms of research methods, one study only used quantitative data to identify the connections between variables, whilst six only used qualitative data. One study employed both quantitative and qualitative data. Recent social media research has begun to be more methodologically varied, by adopting, for example, big data techniques and social network analysis (Greenhow et al., 2019b). Future researchers could investigate such opportunities and utilize different methods to achieve their research goals. When it comes to social media sites, three studies were primarily focused on Facebook and MySpace while others did not identify any specific platforms and instead looked at teens' social media use in general. Though either approach could be used depending on research goals, focusing on specific tools may allow us a more nuanced understanding of different tools (Orben, 2020).

RQ 2: Suggestions for Leveraging Social Media Affordances

The current review identified five social media affordances that can be used to learn about college, indicating that we can use them to better help college-bound teenagers. First, we can support students' technical access to social media by reducing the regulation on the use of phones and social media during the school day. Blocking social media sites at school may separate teens from potentially valuable college information (Brown et al., 2016; Marciano, 2015). According to Enriquez (2011), undocumented immigrant Latinx students found weak ties with other undocumented students to be more useful than teachers, counselors, and school officers in meeting their unique information needs. Teens can possibly use social media to connect with potential weak ties who may provide information tailored to their own situations that they may not be able to obtain at school.

Second, we could integrate social media into curricular activities to benefit from its learning affordances (as suggested by Marciano, 2015). Previous scholars have emphasized the importance and benefits of bridging formal and informal learning contexts with the use of social media attributes (Greenhow & Askari, 2017; Greenhow & Lewin, 2016). For example, we could encourage students to share classroom artifacts via social media by tagging experts and peers to receive help with their work. This way, we can utilize the social media affordances to support schoolwork and have our students associate social media as a learning tool.

Third, we should also help teens improve new media literacy skills to fully exploit the benefits of social media (Brown et al., 2016; Marciano, 2015). New media literacies include traditional literacy such as reading and writing, research skills, technical skills, critical analysis skills, but more importantly, "social skills developed through collaboration and networking" (Jenkins et al., 2009, p. 29). The new media literacy will be crucial in finding credible online resources and making more informed college-related decisions.

Fourth, we could design and develop an intervention for teens' college preparation by using social media affordances. Though many teens use social media on a daily basis, they might not be fully aware of its affordances to help their college-going process. We could let them know the availability of institutions' social media accounts and potential uses of social media to reach out to people attending their dream schools. We could also teach skills to find specific information about colleges using their appropriate hashtags. Such endeavors may involve design-based research aimed at developing an intervention to improve teens' informal learning about college using social media (Greenhow et al., 2019b).

RQ 3: Suggestions for Overcoming Potential Obstacles

Despite all the merits of social media mentioned earlier, this review also highlighted some obstacles teens experience while learning about college through social media. Based on them, I give specific suggestions for practitioners and future researchers. First, educators should provide teens with knowledgeable translators who can help teens make sense of information found online and apply it to their specific needs. Educators themselves could serve as translators for teens at school or district levels. In addition to face-to-face assistance, we could also consider utilizing social media. For instance, school guidance counselors could create a Facebook group page or an Instagram account where they provide college-related information tailored to their students as suggested by Brown et al. (2016). Considering that disadvantaged students are less likely to seek help from guidance counselors (Holland, 2015), using social media as a means to communicate college information could be a possible strategy for making college information more accessible to a larger student population.

Second, researchers should examine how specific social media activities have different impacts on teens' college aspirations. Wohn et al. (2013) found a negative association between teens' frequent use of Facebook and their college aspirations. The frequency indicator may not be sufficient to draw upon to explore how social media usage impacts teens. It is important to stop using the blanket term "social media use" and instead focus on specific social media practices. Future studies should examine what types of social media activities are associated with teens' college aspirations and with their actual college access.

Third, future studies could investigate the impacts of social media friends. The reviewed studies suggested mixed results regarding how social media friends and their emotional support affect teens' college aspirations, which implies the complicated nature of peer influence. Other previous studies have examined how peers on social media can possibly affect teenagers through fear of missing out (Marengo et al., 2021), peer comparison (Chua & Chang, 2016), and drama (Dennen et al., 2018; Rutledge et al., 2019). Such complex phenomena could complicate how social media friends influence teens in terms of their college aspirations.

Fourth, researchers should examine different social media platforms' distinctive features and their impacts on teens' learning about college. This review suggests that a social media norm could be a double-edged sword depending on how teens use it. Future research might look into teens' learning practices on various social media sites, as well as their potential advantages and drawbacks. For instance, Dennen et al. (2020) explored the role of six prominent social sites in a high school environment (i.e., Instagram, Snapchat, Facebook, Twitter, YouTube, and Pinterest). Alhabash and Ma (2017) investigated college students' use of different platforms and nine distinct motivations. Similar to them, we could examine how teens learn about college through various social media platforms and further explore best practices for each platform.

Conclusions

This study reviewed the eight literature investigating teens' use of social media to learn about college. Theoretically, current studies on this topic have been primarily situated in literacy theory and social capital theory. Methodologically, the current studies leaned more toward the qualitative approach. The review suggests five social media affordances in learning about college: vicarious experience, information seeking, identity development, emotional sharing, and schoolwork support. On the other hand, there were some potential barriers teens may encounter when learning about college on social media. First, they were having difficulty understanding generic information obtained online. Second, some social media activities may be detrimental to teens' college aspirations. Third, the norms of social media sites may impede teens from learning about college. This research has implications for how to use social media affordances to better help college-bound teens in their college learning.

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Evaluation of a Sequential Feedback System to Promote Nudge Among Learners and Support Learning Strategies

Takaki KONDO
1720509 @ ed.tus.ac.jp
Master Student
Department of Mathematics and Science Education, Graduate School of Science,
Tokyo University of Science
1-3 Kagurazaka, Shinjuku-ku, Tokyo, 162-8601, Japan

Kyoichi YOKOYAMA
k_yokoyama @ ariake.kaetsu.ac.jp
Mathematics Teacher
Kaetsu Ariake Junior & High School
2-16-1 Shinonome, Koto-ku, Tokyo, 135-0062, Japan

Tadashi MISONO
misono @ edu.shimane-u.ac.jp
Associate Professor
Institute of Education, Academic Assembly, Shimane University
1060 Nishikawatsu-cho, Matsue, Shimane, 690-8504, Japan

Rieko INABA
Inaba @ tsuda.ac.jp
Associate Professor
Development of Computer Science, Tsuda University
2-1-1 Tsudamachi, Kodaira-shi, Tokyo, 187-0025, Japan

Yuki WATANABE
wat @ rs.tus.ac.jp
Professor
Department of Mathematics and Science Education, Graduate School of Science,
Tokyo University of Science
1-3 Kagurazaka, Shinjuku-ku, Tokyo, 162-8601, Japan

Abstract

Note-taking is an effective learning strategy for SRL development. However, due to the lack of opportunities to learn note-taking, learners cannot write complete notes. Therefore, from the perspective of co-regulated learning (Co-RL), we proposed that learners learn note-taking from each other. This study aimed to evaluate NoTAS, a note-taking support system using tablet devices. We asked 33 participants in the experiment to evaluate whether NoTAS promotes Co-RL and note-taking. The questionnaire results showed that the learners using NoTAS can learn and take notes through interaction with others. However, there were some cases where NoTAS prevented learners from note-taking, suggesting the need for improvement.

Keywords: Note-taking, Co-RL, Nudge theory, CSCL, Learning visualization

1. Introduction

1.1. Self-Regulated Learning

OECD (2018) indicated that learners need to develop self-regulated learning (SRL) competencies in the Learning Compass, a vision for the future of education. SRL is the ability to cycle through forethought, performance, and reflection on their own to learn effectively (Usher and Schunk, 2018). In the field of educational technology, much of the research on SRL development has focused on outside class learning support, such as encouraging reflection and learning management using assignments, portfolios, and learning management systems. However, outside class learning support can be burdensome in terms of preparations by teachers and activities by learners. On the other hand, Nilson (2013) proposed note-taking as one of the effective learning strategies for SRL development for in-class learning support.

1.2. Note-Taking and Support Methods

Note-taking has two types of features: encoding and storage functions (DiVesta and Gray, 1972). The encoding function facilitates recognition processing by combining the learning contents with the learner's prior knowledge through writing notes. The storage function enables effective review by reading notes. Morehead et al. (2019) suggest that many learners take notes in class but cannot write complete notes because they have few opportunities to learn note-taking strategies. One of the ways to support note-taking is to distribute class material. Class material clarifies the main points of the lesson (Kiewra, 1989). Furthermore, writing directly on the class material facilitates understanding of the class (Avval et al., 2013). However, only a few learners take organized notes on the teacher's explanations. Therefore, Lannoe and Miller (2019) suggest that more support is needed to encourage more learners to take notes.

Another practical support strategy is to provide feedback on note-taking. For example, Beaudoin and Winne (2009) developed the "nStudy system," which allows teachers and other learners to provide comments and detailed feedback on learners' essays. While "nStudy" can provide detailed feedback, it is difficult for instructors to provide note-taking instruction constantly, and we do not have enough time to share and discuss notes in the class (Nilson, 2013).

1.3. Who Provides Feedback on Note-Taking?

Hadwin et al. (2017) proposed Co-Regulated Learning (Co-RL) as a recent trend in research on regulated learning. Co-RL is a learning to regulate one's learning through interaction with others. Therefore, we suggest that note-taking feedback among learners is possible by applying the Co-RL theory.

In Japan, the Ministry of Education, Culture, Sports, Science, and Technology (MEXT, 2020) has promoted a policy to allow all learners to own devices to develop networks. Thus, many countries witnessed the growing trend of teachers and learners using Information Technology (IT) in classes in recent years. An example of such a feedback system is the "Metaboard," a learning analytics dashboard that supports learners' metacognition and SRL by visualizing their learning behavior (Chen et al., 2020). Furthermore, learners can take notes using a pen and tablet in class without any stress (Özçakmak and Sarigöz, 2019). Therefore, learners can use tablets for longhand note-taking instead of paper and keyboard. However, there is little study on supporting longhand note-taking with tablet devices applying Co-RL theory.

We hypothesize that learners who cannot take notes would be aided by assuming that the notes that many learners were taking were correct and providing them with feedback using tablets. Thus, to promote interaction among learners, we focus on "Nudge theory," which has been studied extensively in the field of behavioral economics in recent years (e.g., Thaler and Sunstein, 2009).

1.4. Nudge Theory in Education

Thaler and Sunstein define the nudge as any element of choice behavior that changes people's behavior predictably without narrowing the choice or significantly changing the economic stimulus (Thaler and Sunstein, 2009). Research on nudge has also been applied to educational studies (Weijers et al., 2020). However, most research is confined to nudging on teaching policies, with little research on nudging the learning strategies among learners in class. Here, we define the educational nudge as improving one's note-taking by referring to the colors and positions of others' note-taking. In this research, we aim to learn each others' learning strategies, such as note-taking in the class.

2. Purpose

In this study, we evaluated NoTAS developed by Kondo et al. (2021) that uses nudge to provide feedback on note-taking among learners in class. We applied NoTAS to subjects and evaluated its effectiveness by using questionnaires. There are two perspectives for the evaluation.

1. NoTAS promotes interaction with other learners (Co-RL) in the class.
2. NoTAS promotes note-taking based on the others' note-taking.

3. Methods

3.1. System Overview

Nudge for Note Taking Assist System (NoTAS) is a note-taking feedback system that can be accessed by up to 45 people at a time, excluding teachers (Kondo et al., 2021). NoTAS is available on web browsers such as Safari and Google Chrome. NoTAS has three functions: note-taking function, learning log function, and visualization function. Learners can use the note-taking function to write notes and highlights text directly on class material displayed on their tablet using their tablet pen. Two types of markers are available for learners to highlight the important parts and the unclear parts. The learning log function has two types: log collection and log confirmation. The log collection allows learners to save their note-taking sequentially as they write and erase notes and highlights in class material. Teachers can view the log of the learners' note-taking processes by specifying the learner (User ID) and the material (Class ID) using the log confirmation. Furthermore, the learning log function uses BASIC authentication so that only certain learners and teachers can access the system. The visualization function is the main of NoTAS. When a learner writes notes and highlights on the class material with visualization function, the approximate location of the notes and highlights written by others on the class material is visualized on the same material in almost real-time.

The interface of NoTAS consists of four layers: note-taking layer, learning log layer, learning visualization layer, and class material layer. On NoTAS, the learner directly writes on

the material that has been distributed via the tablet device. The note-taking layer and learning log layer correspond to the note-taking function. Then, to improve note-taking among learners, NoTAS collects and visualizes information, such as the place and time of writing of all learners, which facilitates learning. The learning visualization layer shows the position and timing of other learners' note-taking. Since this layer overlaps with the number of learners in class, the more learners fill in the same part, the darker the color becomes. As a result, the areas written by more learners are emphasized. Figure1 shows an example of the visualization function of NoTAS. Each color has the following meanings.

- ❿ The red areas mean that other learners wrote notes.
- ❿ The yellow areas mean that other learners highlighted important parts.
- ❿ The blue areas mean that other learners highlighted unclear parts.

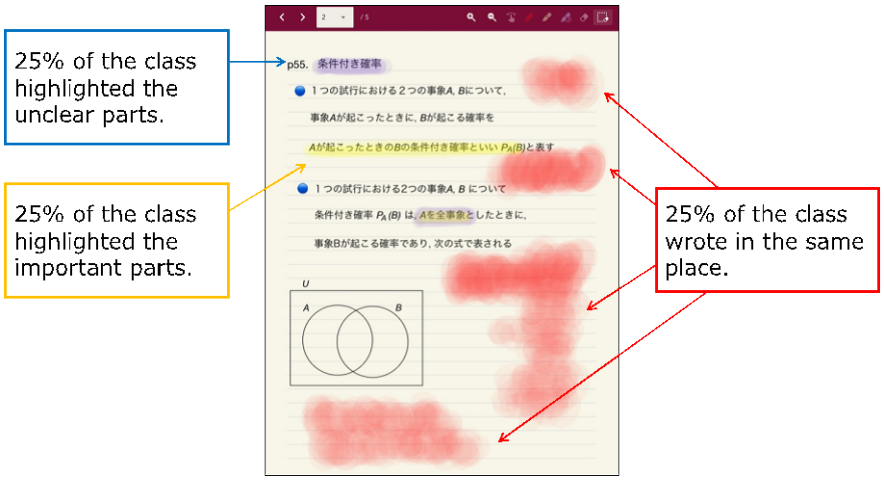

Figure 1. Visualization interface

3.2. Procedure of Research

We recruited university students to evaluate the NoTAS. The participants in this research were 33 students (males: 22, females: 11). The average age of the participants was 22.7 years old. We distributed a tablet (iPad 6th) and a tablet pen to the participants. Before the class, the participants had an opportunity to practice the operation of NoTAS. The experimental group (n = 15) took the class using the visualization function of NoTAS. On the other hand, the control group (n = 18) took the class without using the visualization function of NoTAS. The class content was four instructional design theories, and the participants watched the class video using a projector. Figure 2 shows the procedure of research.

In addition to the participants, five collaborators wrote the contents set by the first author on the class material at a set time. This operation was conducted to verify the effect of the visualization function. We asked the participants on the face sheet, "If they had ever taken a class using a tablet and tablet pen," and found no significant difference between the two groups, $Ç^2(1) = 0.02$, $p = .88$, $Æ = .03$.

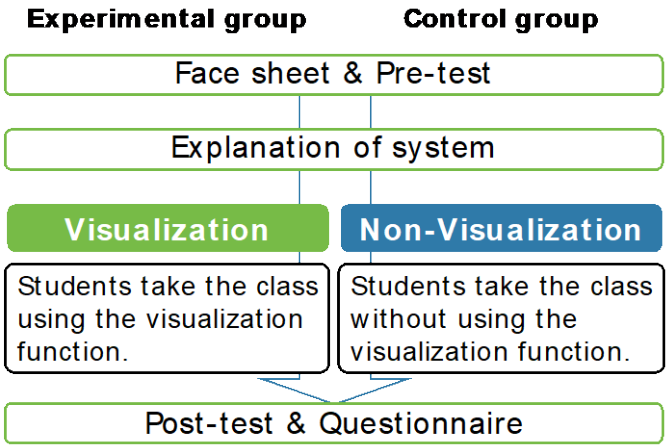

Figure 2. Procedure of research

3.3. Questionnaire

In this research, we surveyed questionnaires from three perspectives as follows:

Community Awareness

We quoted 15 items related to community awareness for Classroom Community Scale (Rovai, 2002). We have partially rewritten the text to be more consistent with the purpose of this study. Moreover, we created and added 3 original items about others' note-taking. We asked all items using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree).

Social Presence

We adopted 3 items proposed by Short et al. (1976) to measure social presence: sociable – unsociable, personal – impersonal, and warm – cold. It employed a semantic differential method with a bipolar 7-point scale.

Note-taking Factor

We created 6 items related to whether learners referred to the others' writing in their note-taking. Moreover, we only asked the visual group 3 items regarding their feeling about using the visualization function of NoTAS. All items used a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree).

3.4. Guidelines for Analysis

We compared the results of the two groups' community awareness and social presence to investigate purpose 1, "Does NoTAS promote interaction with others?" We used these items as a measure to evaluate the promotion of Co-RL.

We compared the note-taking factor between the two groups to investigate purpose 2, "Does NoTAS promote note-taking based on the others' note-taking?" Moreover, we focused on

the visualization group results and compared them with the median of 3.00. The note-taking factor was used as an index to evaluate the nudge.

4. Results

In total, 33 participants answered the three questionnaires. The result of the questionnaires to evaluate Community Awareness, Social Presence", and Note-taking Factors in the class are presented below.

4.1. Community Awareness

Table 1 shows the results of Mann-Whitney U test for the scores of community awareness. The index was reliable (Cronbach's ± = .88). The class in which learners used the visualization function of NoTAS is called "Visual," while the class in which learners did not use it is called "Non-visual." Twelve items found significant difference and marginally significant, visual was higher in all items. However, there were ceiling effects and floor effects except for No. 7. Therefore, the learners felt that they were receiving real-time feedback on their note-taking by using NoTAS.

Table 1. Comparison of community awareness

	Visual		Non-visual		M_1-M_2	U		r
	M_1	SD_1	M_2	SD_2				
1. I felt that learners in this class cared about each other.	2.60	1.35	1.89	1.28	0.71	90.50	†	0.33
2. I felt that I was encouraged to ask questions.	2.53	1.19	2.22	1.00	0.31	114.00		0.16
3. I felt uneasy exposing gaps in my understanding.	3.93	1.49	3.50	1.43	0.43	112.00		0.17
4. I felt connected to others in this class. (R)	4.00	1.13	1.11	0.32	2.89	2.00	***	0.99
5. I did not feel a spirit of community. (R)	3.53	1.36	1.61	0.78	1.92	34.00	***	0.75
6. I felt that this class resulted in only modest learning because of using NoTAS. (R)	3.73	1.34	3.11	1.37	0.62	99.50		0.26
7. I felt that I received timely feedback on my notes and highlights in this class.	3.53	1.13	2.00	0.84	1.53	41.50	***	0.69
8. I trusted others in this class.	2.93	1.49	2.67	1.14	0.26	122.50		0.09
9. I felt isolated in this class. (R)	4.27	1.10	2.94	1.16	1.33	56.00	**	0.59
10. I felt that I could rely on others in this class.	3.33	1.29	1.44	0.71	1.89	34.00	***	0.75
11. I felt that other learners did not help me learn in this class. (R)	4.13	0.92	2.72	1.23	1.41	49.50	**	0.63
12. I felt that members of this class depended on me.	1.60	0.74	1.22	0.55	0.38	95.00	†	0.30

13. I could feel how the other learners were listening to the teacher's explanation in this class.	4.20	1.27	2.50	1.30	1.70	46.00	***	0.66
14. I felt uncertain about others in this class. (R)	3.53	1.25	2.78	1.40	0.75	94.00		0.30
15. I found that the other learners were taking notes very hard.	4.53	0.64	3.67	1.03	0.86	68.50	*	0.49
16. I felt confident that others would support me.	3.00	1.20	1.61	0.85	1.39	49.50	***	0.63
17. I felt that I had enough opportunity to learn how to take notes in this class.	3.27	1.39	3.06	1.16	0.21	118.00		0.13
18. I was curious about others' note-taking behavior.	4.00	1.46	2.83	1.43	1.17	61.50	**	0.54

Visual: $n = 15$, Non-visual: $n = 18$ $^{\dagger}p < .100$, $^{*}p < .050$, $^{**}p < .010$, $^{***}p < .001$
(R): Reverse score, 5-point Likert scale

4.2. Social Presence

The social presence score was the average value of the three social presence items. The result of Shapiro-Wilk test showed that this score was normally distributed. Moreover, the result of Levene's test showed that this score was equality of variance. Table 2 shows the results of Student's t-test for the social presence score. The index was reliable (Cronbach's ± = .88).

Table 2. Comparison of social presence

	Visual		Non-Visal		M_1-M_2	t		r
	M_1	SD_1	M_2	SD_2				
Social presence score	4.89	1.12	3.46	0.79	1.43	4.28	***	0.81

Visual: $n = 15$, Non-visual: $n = 18$, Semantic differential method $^{***}p < .001$

As a result, the visual's score was significantly higher than the non-visual' score. Therefore, learners can feel a higher social presence of others by using visualization of NoTAS.

4.3. Note-taking Factor

We compared the six note-taking factors (No. 1 to 6) between the visual and non-visual groups. All items were significantly higher in the visual group. However, we found a floor effect for all items in the non-visual group for the note-taking factor. We expected this result because the learners who did not use the visualization function of NoTAS could not watch the others' note-taking.

Then, we compared the values for the visual group with a median of 3.00. Table 3 shows the results of One-Sample Signed Rank Test for the value of note-taking factors. The index was reliable (Cronbach's ± = .83). We asked only the visual group about No. 7 to 9.

Table 3. Note-taking factors

	M	*SD*	*M*-3.00	*W*		*r*
1. I wrote the "teacher's writing" based on the notes and highlights of other learners.	3.47	1.51	0.47	71.00		0.18
2. I wrote the " teacher's oral explanation" based on the notes and highlights of other learners.	2.80	1.47	-0.20	39.50		0.34
3. I highlighted "the important points" based on the notes and highlights of other learners.	3.33	1.45	0.33	58.00		0.03
4. I highlighted "the points I did not understand" based on the notes and highlights of other learners.	2.40	1.06	-0.60	6.00	†	0.90
5. I wrote "symbols" based on the notes and highlights of other learners.	2.80	1.42	-0.20	26.00		0.57
6. I wrote in "diagrams and tables" based on the notes and highlights of other learners.	2.67	1.35	-0.33	26.00		0.57
7. The visualization prevented me from writing my notes. (R)	2.13	1.13	-0.87	17.00	**	0.72
8. The visualization prevented me from writing my highlights. (R)	2.87	1.60	-0.13	57.00		0.05
9. I enjoyed note-taking with the visualization function of NoTAS.	3.07	1.62	0.07	50.50		0.16

$n = 15$, (R): Reverse score, 5-point Likert scale $^{\dagger} p < .100$, $^{**} p < .010$

As a result, learners tended not to refer to others' highlights when they highligted parts they did not understand, $W = 6.00$, $p < .100$, $r = 0.90$. Furthermore, the visualization of NoTAS interfered with the learners' note-taking, $W = 17.00$, $p < .010$, $r = 0.72$.

5. Discussion

5.1. NoTAS Promotes Interaction Among Others

The results of community awareness suggest that the learners felt the interaction with other learners by using the visualization function of NoTAS. For example, they felt connected to others and felt that other learners helped them learn and note-taking. Furthermore, the learners felt that they were receiving sequential feedback on their note-taking using the visualization function. On the other hand, learners did not feel that they had enough opportunities to learn note-taking even though they used the visualization function of NoTAS. We suppose that this is because this study was a short-term experiment. This result suggests that learners learn more about note-taking by using the visualization function of NoTAS in the long term.

The social presence score suggests that the visualization function of NoTAS makes learners feel more social presence. Moreover, the visualization function helps learners recognize others' presence and promotes interaction among learners.

Therefore, we found that NoTAS promote Co-RL.

5.2. NoTAS Promotes Note-taking Based on the Others' Note-taking

From the results of the note-taking factor, we found that learners who used the visualization function wrote their notes based on others' writing more than the others who did not use this function. The visualization function of NoTAS automatically shares with learners the color and location information of others' notes and highlights. These results suggest that learners write notes and highlights using this visual information.

However, the mean scores of the visualization group were below 3.00 for many items. These results suggest that the visualization feature of NoTAS did not contribute much to the learners' note-taking. Furthermore, we found that the visualization might interfere with note-taking. There are two possible reasons as follow:

- ❿ The learners are not familiar with NoTAS
- ❿ The density of the visualization layer is set too high

As a future task, we need to have learners use NoTAS for a long time and evaluate their note-taking. Furthermore, the density of the visualization needs to be reduced.

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Knowledge Convergence in Collaborative Concept Mapping

Minkyung Lee
College of Education
Penn State university
mzl263@psu.edu

Roy Clariana
College of Education
Penn State university
rbc4@psu.edu

Amy Garbrick
College of Information Sciences and Technology
Penn State University
alh245@psu.edu

ABSTRACT

This study investigates how collaborative concept mapping tasks affect the knowledge convergence of learners. Participants are divided into two groups by different group contingency, independent and interdependent, and we analyzed their discourses. We observed that agency could strongly affect their collaboration, but verbatim recitation was not a strong indicator of knowledge convergence in this context where learners had created an individual map before collaboration, and they used it as a reference. Though we also found the process of knowledge convergence, that did not strongly indicate that learners build knowledge together in both groups. Their actual collaborative map with an informational text was not considered as the knowledge convergence outcome.

INTRODUCTION

Online discussion, either asynchronous or synchronous, has been emphasized since social interaction was one of the critical capabilities for this new normal era, according to OECD (2019). However, efforts devoted to the study of group achievement and understanding have been significantly lacking, considering the new understandings built through dynamic interaction (Fisher & Mandl, 2005). This paper extends the investigation of in-depth learning, focusing on collaborative achievement, particularly knowledge convergence, while constructing a collaborative concept map. In this study, we engaged Information Science and Technology undergraduates in collaborative concept mapping to do the summary activity of a chapter, and we analyzed learners' knowledge convergence by different group contingency from their discourse. The finding from this study can inform the development of practical instructional support within the context of learning linearly arranged information.

THEORETICAL RATIONALE

Dillenbourg (1999) defined collaborative learning as two or more people's attempts to learn something together compared to cooperation. Team members individually solve sub-tasks after splitting the work and assemble the individual's results for the outcome in cooperation, whereas individuals share and negotiate for the outcome in collaboration. Roschelle & Teasley (1995) also defined collaboration as a coordinated and synchronous group activity as a result of individual learners' consistent effort to construct and develop a shared conception of a problem. Concept mapping is a visualizing technique to organize and represent the relationships among nodes(concepts) by edges (connecting nodes) representing relationships among the concepts as a network of ideas as a part of qualitative methods (Novak & Gowin 1984; Novak & Canas, 2008). Concept mapping tasks are generally regarded as cognitively demanding tasks given complex procedures such as identifying the main concepts and finding relationships among nodes by focusing on the organizational structure of the text, simultaneously screening the learning materials (Jonassen 1997; Hay, Kinchin, & Lygo- Baker 2008). These tasks generally improve verbatim knowledge and comprehension, and inferential skills for the contents (Novak & Gowin 1984). Thus, as a learning strategy for knowledge construction, collaborative concept mapping can certainly enhance conceptual understanding (Stoyanova & Kommers 2002; Farrokhnia et al., 2019). Collaborative concept mapping tasks are essential strategies to integrate individual learning with various group learning skills, such as creating a shared meaning of the task, concepts, procedures, and strategies for knowledge construction (Van Boxtel et al., 2002). Bereiter and Scaldamalia (2003), who appear as the pioneers in the field of knowledge construction, insist the creation of knowledge only occurs in collective processes, and Jeong and Chi (2007) indicated that in-depth learning only occurs after the group members integrate reasoning into personal understanding with the shared meaning. Knowledge convergence, essential to evaluate the depth of understanding of learners, mainly focuses on mutual influence through social interaction; as such, it is a process where two or more people exchange and converge their knowledge of the problem. Through mutual understanding, the knowledge finally becomes similar, which can be called 'shared understanding' of the content (Hutchins, 1991; Rogoff, 1998; Jeong & Chi, 2007; Roschelle 1992).

Processes and outcomes are often used to explain knowledge convergence (Roschelle 1992; Jeong&Chi 2007; Fischer&Mandl 2005). The process of convergence is conceptualized in various ways. One approach is based on knowledge contribution, which emphasizes that learners should contribute the ideas to varying or similar extents by counting the number of turns in discussion (Cohen 1994). This process can include grounding (Clark & Brennan, 1991), where both parties believe both understood and contributed to the discussion. The grounding process is the bottom layer of negotiation (Dillenbourg et al., 1996) and an essential part of achieving convergence. Shared knowledge, group mind, community memory, and team mental model are often viewed in the process of knowledge convergence as contributions of mutual knowledge. However, grounding may only capture the local convergence, not lead to a global convergence in terms of both mental models (Chi et al., 2004). Roschelle (1992) indicated that conversational analysis (CA) and pragmatics are critical in knowledge convergence research as interaction provides a means to construct abstract concepts collaboratively through the gradual refinement of ambiguous meaning. In addition to knowledge convergence processes, the other aspect to explain this phenomenon is resulting outcomes or mutual understanding. The outcomes can be defined in one way as "increased similarity in the cognitive representations of the group members" (Jeong & Chi, 2007, p 288) as their knowledge will be incrementally elaborated. That

is, learners mutually influence the knowledge outcomes of the group members; common knowledge or common ground are examples of outcomes of this mutual influence (Roschelle 1992; Teasley 1997; Jeong & Chi 2007; Mercier 2017). In Roschelle (1992)'s study, the outcomes of two learners were gradually similar, indicating that the similar representation as an outcome after collaboration is convergence. For example, each learner interprets a situation, adjusts their understandings, and collaborates to solve problems; this process leads to the outcome of convergence. Jeong and Chi (2007) assessed knowledge convergence quantitively by conducting pre and post-knowledge tests to see the increase in common knowledge within the group; they defined knowledge convergence as an increase in common knowledge within a group. The results of pre and post-test performance revealed that learners shared more knowledge pieces and mental models after collaboration, though the association between the amount of interaction and the increase in common knowledge was not statistically significant. The study design considered the influences of learning artifacts (e.g., concept map) besides collaborative dialogues. Another study using pre and post test measures to quantify the knowledge convergence outcome differences when students had different goal assignments (either a learning goal or a performance goal); was conducted (Mercier, 2017). Though the results did not represent the differences in having learning goals or performance outcomes, there was a difference in knowledge convergence; groups with learning goals showed more knowledge convergence than groups with performance goals, suggesting that creating achievement goals for collaboration can influence interaction behaviors.

Peterson & Roseth (2016) developed four CSCL (Computer Supported Cooperative Learning) strategies to increase students' cooperative perceptions based on the social interdependence theory: social interdependence, summarizing, scripts, and synchronicity. We particularly apply three relevant strategies to examine this small-scale research. Social interdependence (Johnson & Johnson, 1989, 2005) describes how students perceive their success as being affected by others' works, so hypothetically, the interdependent group has a more positive perception of their collaboration than the independent group. Additionally, requiring students to work on a collaborative summary should enhance collaborative perceptions because the shared goal involves active collaboration to create a group product (Ortiz, Johnson, & Johnson, 1996). Summarizing enhances achievement encouraging students to focus on the most relevant material and integrate it with existing knowledge (Hidi & Anderson,1986; Wittrock & Alesandrini, 1990), and using concept maps for summarization can even double the effects on text comprehension (Chang, Sung & Chen, 2002). In short, the greater positive goal interdependence by adding summarizing tasks with concept maps could enhance the benefit of collaboration, increasing the group productivity. Another essential part of this research is synchronicity. A synchronous video conferencing tool can enhance their collaboration by allowing them to convey social cues negotiating to construct knowledge in real-time, and researchers to analyze the processes of constructing a concept map during collaborative works. Therefore, it is critical to study knowledge convergence using a concept map with the concept of social interdependence in synchronous discussion in computer-supported learning to understand their deeper learning. This research investigates whether participants interact to share their individual knowledge and improve their conceptual understanding. Additionally, we explore their term usages to understand which terms are more frequently used together and how the terms in the interdependent group differ from the independent group.

METHOD

It occurred within the Information Sciences and Technology introductory course of 80 students at a Northeastern American university. For this particular paper, we randomly selected one independent and interdependent group to compare and analyze their discourses to understand how the collaborative concept maps are constructed differently by the group contingency to find evidence of deeper learning.

Procedure

Each group comprised three students, and they were randomly assigned to either an independent or interdependent group. The independent group students read one chapter about "system design and development" and constructed an individual concept map using the given tool, whereas the interdependent group students read one-third of the chapter and constructed an individual concept map using the same tool. After this preassigned task, both groups synchronously met and collaborated to create one map for the group. During the collaboration, students were required to create at least 20 nodes with edges but were not asked to consider the directionality of the nodes. Students were told their options not to be included in the research without any negative influences at the end. There was no time limit, and participants could look at other team members' maps. A tutorial of a tool, Cmap (Novak & Canas, 2008), was provided to instruct how to place words(nodes) with links (edges), including the directionality in advance.

RESULTS

Lexical network analysis

Based on the content-related term frequency in two transcripts, we created their lexical networks in different group contingencies and compared them to understand the difference by the group. We picked 40 relevant terms from the most frequently used terms, and networks joined in pairs by edges were generated. Modularity, based on the eigenvectors of a characteristic matrix for the network, is a highly effective measurement technique in network analysis to detect delineated clusters (Newman 2006). With this definition, we found four different term clusters with 17 nodes and 51 edges in group 1(independent) and seven clusters with 22 nodes and 114 edges in group 2(interdependent). Simply describing, there are more nodes so as more clusters and the terms in each cluster were different in groups. Though each cluster includes identical terms, slightly different terms in clusters were found by the groups—also, the average degree and average weighted degree of the interdependent group was 5.182 and 9.090, which is relatively higher than the independent group of 3 and 6.647. The graph density of both groups is low and cannot be compared because of the different numbers of nodes(Table 1).

	Independent	Interdependent
Average degree	3	5.182
Avg.Weighted Degree	6.647	9.091
Network Diameter	5	4
Graph Density	0.188	0.247
Modularity	0.303	0.204

Table 1 Lexical difference in groups

Discourse Analysis

Roschelle (1992) indicated that conversational analysis (CA) and pragmatics are critical in knowledge convergence research as interaction provides a means to construct scientific concepts collaboratively through the gradual refinement of ambiguous meaning. In his case study, the dialogues of a pair of high school students were analyzed when they collaborate to learn the concepts in physics within the concepts of conversational action, conceptual change, and shared knowledge.

Craig, Rick, and Julien (Group 1) and Malissa, Josh, and Bryce (Group 2) are undergraduates taking an introductory course in information science. The main difference in the tasks between the two groups is the content they read. The members of group 1 were assigned to read a whole chapter, while the members of group 2 were required to read one-third of the chapter. After that, group 1 individually constructed a whole map of a chapter, while group 2 members created only one-third of the map before their collaborative work. The evidence of social outcome is shared knowledge as a process for knowledge convergence. During the collaboration, ideally, learners interpret a situation, coordinate their understandings, and come up with a solution to a problem together, and this process leads to the outcome of convergence. Here we focus on knowledge convergence in socially shared meaning, and we found knowledge convergence in both groups but could not conclude their collaborative map is their knowledge convergence outcome.

Agency by grouping

"Agency refers to the capacity of an individual or group to affect change on some entity, person, experience, state… and it is also connected with the notions of power and control (Strauss and Feiz, 2014, p.293)." Two groups were required to construct a collaborative map after different task requirements: group 1 members were asked to read a whole chapter, while group 2 members were to allocate their reading by one-third of the chapter per individual for the knowledge dependency. We expected group 2 to be socially dependent on their achievement as the outcome is more likely to be affected by other members' commitment and knowledge.

Group 1, whose task was to read a whole chapter individually, caused to rise of a dominant leader. Grammatical and conceptual connotations of his utterance with controlling attitudes signified the role in the group. In their previous conversation, Craig asked what other nodes connected with the node of programming languages, and Rick suggested having programming as a node and branch off to higher-level language and lower-level language. In the excerpt below, Craig uses imperatives to provide direction, and the rest of the members agree and follow. When Rick suggests branching macro language off languages, Craig says, "that's what I will do." This sentence represents his way of agreement. Also, asking an obvious question is often used as a means of control.

Group 1- Independent

Craig – OK so then we're over here. I'll connect those in a second, just give me a sec. We'll put high level languages over here, and then while I'm connecting that you guys, uh, work on high level languages. We don't need a ton, I mean as long as we get some.

Julian – Yeah, um… low level…assembly…machine…low level…high level… [reading out of book to himself]

Craig – OK, uh…high level languages…[mumbling a little] algorithm. Oh OK, Ricky. I got you. I see what you're doing. OK, so high level languages… is that like basic and C and C++?

Rick – Yeah.
Julian – Yes.
Rick – You could also branch, uh, macro languages off of languages.
Craig - OK, that's what I'll do. Now do we have to cover the whole chapter?

Group 1- Independent
Julian - Did it – did it go across? It doesn't matter about that.
Craig – OK. Um, if you wanna move – Julius, if you wanna move Java up to the high level languages up there and I already got C++, so if you wanna move FORTRAN and- and Java up there, go ahead. OK Ricky, for macro you just had 4th generation and 5th generation?

This excerpt above is a dialogue between Julian and Craig. While Julian was constructing a part of the map individually, his link(edge) crossed the part Craig was working on. He overly reacted and indirectly instructed Julian what to do, limiting his work, and promptly changed the attention by talking to Rick obstructing utterance of Julian. These two excerpts describe his dominant behaviors showing the agency of the group. Unlike our assumption that the independent group will be more collaborative than the interdependent group because of the different content distribution, the independent group worked more cooperatively, and the agency was affected.

Group 2 represents distributed agency. Bryce interpreted the situation by asking a question about a task, and Josh provided solutions by mentioning other team members' maps shared in advance. In their decision-making process, they coordinated their understanding and came up with a solution how they wanted to work on, though the process took a long time. This is rather a collaborative process of decision-making than knowledge building of the learning content. Each member had authority or expertise in terms of the book knowledge because they all read the different sections of a textbook and constructed relevant parts of the map individually.

Group 2- Interdependent
Josh –so, if we just take systems design and development, put like a couple nodes off of it, then we can each tackle one of those nodes and just get the [Brian – Yeah.] high- the first two levels done – and then split off of a second tier.
Melissa –Right.
Bryce – Yeah.
Josh – Is that the three main categ – is that what they're – what they're - it's how people make programs, [garbled] programming languages and methodologies, and what else is there? Or is that it? Programs and perspectives? Systems analyst – analysis – and systems [garbled]?
Melissa – Yeah, it's right here…three nodes.
Josh –Then there's the science of computing. The next one…
Melissa – State of software.
Bryce - Oh, I see what you're doing. You're going through each thing.
Josh - Yup. And…that's it.
Bryce – That's it.
Josh – That's it.

Bryce – Um…OK. So, Melanie, for yours system development [Melanie – Yeah.] and lifecycle, your main points are analysis – I'm gonna write these down – analysis, design, development…
Melissa- Um, OK, sorry my screen is really small so I have to go back and forth. Um, analysis, design, development, implementation…
Bryce- I'll help you.
Josh - You want me to – [Melanie – Yeah.] is it cool if I start going from the beginning? I'll just start, start from the 'how people make programs'?
Bryce – Yeah, yeah. Um, retirement… um, implementation…oh maintenance, Melanie? OK and then…
Melissa –Is that all we really need for that, or do we wanna go in-depth at all?
Bryce – So with retirement we can do 'in with the old', the 'out with the new'.
Melissa – Let's see…
Bryce – Um, implementation…one of them is approaches to implementation.
Melissa – Yeah.

In the first excerpt, about 40% of the dialogue is to express agreement. Josh suggested creating a node, "system design and development" to begin, and the collaborative map was developed with each of the personal maps. After that, Bryce checked the assigned parts, and Josh created a few key nodes from his part, asking other key nodes to connect with. This excerpt reveals that Josh is leading the direction but not in a completely authoritative manner. The second excerpt represents Bryce helping Melissa to find relevant terms to connect with retirement and implementation. Again, there was no dominant leader in group 2. When the groups are compared regarding agency, the nature of group 2, distributed content expertise, made them cooperate more with positive social dependence. In contrast, the members in group 1 had the same content knowledge, even having a personal map of the content, so ideally, they were supposed to collaborate to negotiate the connection among nodes. However, instead, one dominant figure led the group conversation with relatively low social dependence.

Verbatim knowledge as a strong indicator of shared knowledge

Verbatim knowledge often refers to the items stated directly from the original text, such as remembering facts and stating knowledge as a lower order thinking, while inferential knowledge(conceptual knowledge) refers to the items needed to connect multiple concepts such as concept formation and problem-solving as higher-order learning (Clariana & Koul 2006; Blunt & Karpicke 2014). The concept mapping tasks require both verbatim and inferential knowledge given the complex procedures of identifying the main concepts and finding relationships among nodes by focusing on the organizational structure of the text while viewing the learning materials (Novak & Gowin 1984).

The unique and confounding aspect of this dataset is that all participants have their reference maps when collaborating to construct the group map, but retrieving and reciting those individual verbatim knowledge maps cannot be the evidence of shared knowledge. Thus, the verbatim knowledge we consider here is only when they refer to the textbook. Both groups referenced their textbook but were rare because of the personal reference maps. The behavior referencing their textbook appeared when checking the connections among nodes.

Group 2- Interdependent
Bryce – What stuff? That's um…programming languages and methodologies.

Josh – What does that connect to?
Bryce – Uh…let me open my [cut out] page book.
Josh – That go…
Bryce –…connect off the center. I hate this thing. So people make programs, and then programming languages and methodologies.

Group 1- Independent
Craig- Is computer science and the science of computing – are they the same thing?
Julian – Com…
Rick – Wait, what's that?
Craig – Uh, if you – the science of computing and computer science. Are they one and the same? Are we saying the same thing there?
Julian – Uh, the, um, that starts off the, um… it starts it off. If you look on 536 –
Craig – Yeah.
Julian -that's the title: The Science of Computing.

Knowledge Convergence

Interesting part in this discourse data originates from the artifacts: individual concept mapping. As all participants construct their personal concept maps based on their assigned reading before joining a collaborative work, their knowledge should be reflected on those individual maps, which are frequently referred to during discussion in both groups. Thus, we could induce that their references in these dialogues are mostly from their personal maps and could assume that when participants refer to their own maps during the group map construction (identifying the concept), negotiation occurs, and their group maps reflect their negotiation (finding relationship among nodes), we could see them as a process of knowledge convergence.

Group 2 Interdependent
Josh - …going to connect this here. This guy really needs to go here.
Bryce – What's up?
Josh - I, I'm only, I, I'm double linking up here…going crazy.
Bryce – Wait why are you double linking?
Josh – I – cause it make sense, I guess? I don't know where I'm going…[garbled] cross the stream.
Bryce – Do that magic thing to it.

In the excerpt above, Josh tried to double link with one node, and Bryce asked why he wanted to do it, which could be evidence of negotiation if Josh explained the reasons, but Josh intuitively did it saying "cause it make sense, I guess". To them, the auto-format function, "magic thing," seems like a convenient backup skill to verify their map. This excerpt is interesting considering the aspect of knowledge convergence: Josh brought a double linking problem and cannot explain the reason. Josh and Bryce both could have referenced the textbook, but instead, Bryce suggests auto-formatting, which might solve the problem without the retrieval process, whether that is either verbatim or conceptual knowledge. Thus, we cannot find the clues of knowledge convergence.

Group 2 Interdependent
Melissa – What still needs done yet?

Josh -…program with machine language.
Bryce – Are we going to put everything underneath, or…what did you guys wanna do? I guess we'll…
Bryce – I guess we can let it auto format? Or do you wanna –
Melissa – Well the systems lifecycle should be closer to the bottom cause that was like the end of the chapter.
Bryce – What? Oh are you saying this – is this wrong? Well would – I thought this would be the center and then there would be arrow pointing to each. Is that incorrect?
Melissa – No, no, I mean that's fine. It's just like the systems development comes after the programming languages – in the chapter, at least.
Bryce – I think we're good.
Melissa – Yeah.

In the excerpt above, they are checking the parts in the map not completed yet. Josh found a part (program with machine language) that needs attention, and Bryce suggested intuitive solutions, either putting everything underneath based on his knowledge or autoformatting. Melissa doubted his solution as she thought the node should go down to the bottom of the map because she assumed the terms in the textbook are chronologically delivered, which is incorrect. Bryce expressed his thought with reasoning, and Melissa did not rebut the point Bryce made but confirmed her understanding was slightly inaccurate in that system development should come after the programming languages. This dialog looks like a weak version of the negotiation process.

Group 2 Interdependent
Josh – It's gotta go there like that. That guy's gotta go there. [last part garbled] …get this over here…and then put this one…
Bryce – Do you just wanna do the [middle part cut out] the whole thing?
Josh – Uh it gets, I mean if we do it, we can try- we can try it out – Whoa! Whoa, what's go- what just happened? Hold on.
Melissa – Oh no.
Josh – That made no sense. Yeah that got bad real quick. Um the auto-format thing can sometimes mess up, so if we do it we gotta just one person do it so they can -can- they can undo it if it doesn't look right. But I think we're looking kinda good. It's pretty good. Well except for that one down there.

Before this excerpt above, the auto-formatting function had helped them organize the map, which led them not to deal with complex conceptual understanding connecting distributed concepts. Josh structured the map, and Bryce wanted to use the autoformat function again to make sure Josh was right. They realized this function does not always provide the solution indicating this team could at least notice when the map goes wrong. Each member's knowledge was not entirely engaged in this collaborative concept mapping process: they tried to solve problems working on the group map but did not show deeply engaging conversation using their individual knowledge.

Group 1- Independent
Craig – OK Rick, would you say macro languages off of languages as well?

Rick – Yeah...so then there's um, you can have 4th generation languages and 5th generation languages.
Craig –for macro you just had 4th generation and 5th generation?
Rick – No, uh, make, make those just go off of languages too.
Craig - Oh just – oh just keep macro languages by itself then?
Rick – Yeah.
Craig – OK.
Rick – And under 4th generation you could have query language. And that's all I had for – that's all I had before for that.

Craig - OK and you want me to do languages by itself?
Rick – Yeah like have, uh, programming like branch off of languages.
Craig – Like that?
Rick – Yeah and then connect them. Yeah.
Craig – OK, OK. So we do programming, we do languages. I remember there's – there's like what? There's hi – there's, uh, low level and high level languages, right?
Rick – Yeah.

In the above two excerpts, members structurize the map to organize terms. Their dialogues above are questioning from Craig and answering and confirming from Rick. Craig primarily relies on the opinions of Rick, and Rick refers to his personal map. There is no further negotiation process as proof of converging knowledge, so their symmetry of knowledge in the content seems slant toward Rick even though all are supposed to read a whole chapter.

Group 1- Independent
Craig- computer science as one and then, um, off of computer science I actually had a ton, so I'll work on that and then the other- the other big one that I had was system development lifecycle. I'm not sure if you guys had that or not.
Rick – Wait, what was the first one you had?
Craig – Computer science.
Rick – OK.
Craig – And then off of that was like I had – uh, actually from that one right there, that node – I had computer theory, algorithms, data structures, uh, programming concepts and languages, management information systems, software engineering, and computer architecture. There's a ton.
Rick – Yeah… Maybe we should put a node for like, um, chapter four – the name of chapter 14 somewhere? Then we could connect like the two main ones to that.
Julian – That's – that's what we started with.

In comparison to the interdependent group (group 2), the collaboration of group 1 was superficial even though we assumed they were supposed to have an in-depth discussion as all members read the entire chapter. For example, some cognitive outcomes, a conceptual change based on the verbatim knowledge from the textbook, were expected by in-depth discussion to construct the map but not observed. There were some moments of shared knowledge, such as checking where each one is at in order to discuss from there, but that did not clearly represent knowledge convergence. The shared knowledge here is considered as a contribution of mutual knowledge in the process of grounding.

When it comes to the Cmap tool, group 1 did not desire to explore other functions besides connecting nodes to construct a map, whereas group 2 used the tool effectively to connect a chunk of nodes to another chunk though it became a time-saving tool not to do complex thinking. Whenever they were in problems connecting vertices, they agreed to use that auto format though they eventually learned this function did not always work. Finding relationships among nodes by focusing on the organizational structure of the chapter involves inferential and higher-order thinking.

Agency in knowledge convergence

We examined how the distributed agency affects the knowledge convergence compared to the concentrated agency. A context engenders different levels of collaboration: the collaborative work is more likely to be effective with people having a similar status and action (Dillenbourg, 1999). The agency particularly influenced the symmetry of action in this case. Craig's controlling and initiative manners led to unbalanced communication in collaboration. For example, turn-taking between Craig and Rick and Craig and Julian was more than 95%. From the beginning, Craig referred to Rick's map complementing and asked his opinions, and those Q&A style interactions were maintained until the end. His questions at the beginning were to distribute their mapping tasks and later to ensure specific nodes with links were right. Craig mainly initiated conversation without intent to learn; he has never tried to validate reasons or rationalize the concept, so there seem rare opportunities to converge their knowledge while constructing the map. This discussion, driven by one leader with this type of conversation, Q&A, did not lead members to converge their knowledge to identify the main concepts and find relationships among vertices.

However, the members of the interdependent group with the relatively distributed agency were more actively participated in elaborating the map by finding relationships referencing their textbooks. This distributed agency positively affects knowledge convergence. There were conflict-oriented consensus and integrate-oriented consensus (Weinberger and Fischer, 2006). For example, when Bryce asked the overall structure of the map to connect different chunks of nodes, two members replied, and that process went on for a couple of minutes (shared knowledge) while looking at the common map to decide the path of some nodes. Even though certain words were not explicitly spoken, interlocutors understood, and they maintained their interaction. Regarding the tool, they had a good collaborative process while exploring the tool; Josh tried to use a specific tool function, auto-format, to organize it. Melissa knew how to do it, and Bryce was interested in applying it.

Group 1- Independent

Craig- Um, tell me what goes, uh, Julius – what I would go to from low level languages?
Rick – Well low level's, um, machine and assembly languages.
Julian – Yeah I see machine, yeah.
Craig – OK hold on.
Julian – It says, it says, uh, machine, assembly, assembler, and low level.
Craig – OK.
Julian – And high level is completely separate.
Craig – OK. Machine is one –
Julian – So you could –
Craig – What – what are the other ones? Assembly?

Julian – Yes.
Rick – Yeah.
Craig – And what was the third one?
Julian – Um... low level.
Craig – Oh I thought machine and assembly were low level? Oh I think that's it.
Rick – Those are the only two that – those are the only two I had in mine.

CONCLUSION

Online discussion, either asynchronous or synchronous, has been emphasized as an effective instructional strategy. In this research, we tried to investigate knowledge convergence while constructing a collaborative concept map, and little knowledge convergence as a clue of deeper learning in these two cases was found. The required individual task, drawing a concept map in advance, influenced collaborative work as most students rely significantly on their individual maps regardless of their groups, which is likely to reduce the situation for socially sharing meaning. Having an additional artifact, a concept map, obstructs students' discussion, so even if there was knowledge convergence, that was not observed. Also, creating a concept map with the unfamiliar tool was already an arduous task whose cognitive loads are probably negatively affected. That is, there were too many confounding factors to affect their knowledge convergence in their collaborative work. Instead of negotiating to connect nodes, students just used a certain function of the tool to avoid complex thinking, intuitively connected nodes, and passively accepted others' thoughts. Furthermore, knowledge convergence was not frequently observed in collaborative work when the content builds foundational knowledge. The group difference reveals a slight difference in their collaborating process in extent, but we could not find an absolute difference in knowledge convergence by analyzing the discourse in terms of grouping.

Finally, a verbatim recitation of a concept or inference rule was searched as this will be the strong evidence of shared knowledge. Their verbatim recitations were either from the textbook or their individual maps, but these recitations were not evidence of shared knowledge. Those citations were only the references. We assume it is because the content itself is not meaningfully interrelated but linearly arranged to the novice, unlike the concepts of Physics (Roschelle 1992). There still can be a negotiable place for knowledge convergence, but participants should understand the contents more thoroughly to interactively communicate for negotiating to link the nodes to reach that point. Future research will be needed to focus more on the attributes of knowledge convergence and design the intervention accordingly.

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Exploring the Characteristics of Instructional Design Professional Knowledge from a Facebook Community of Practice (CoP)

Javier Leung, PhD Candidate
School of Information Science & Learning Technologies
College of Education & Human Development
University of Missouri

611 Conley Ave, Columbia, MO (USA)
leungj@missouri.edu or javier.leung81@gmail.com

Abstract

Online communities of practice (CoPs) in Instructional Design play an important role in creating and transferring professional knowledge (tacit knowledge). This study examines the characteristics of professional knowledge from 4,717 anonymized users' posts available in the Instructional Designer Facebook group from August 3rd, 2017 to September 9th, 2020. This group is the largest public group on Facebook with 17,640 members as of September 29th, 2021 (About Us CrowdTangle, n.d.). Natural language processing approaches, including n-grams, sentiment analysis, visualization of named entities, and topic modeling, were implemented to extract tacit knowledge from written forms of communication. Three topic models, including bag-of-words, TF-IDF, and sentence embeddings, showed topics related to corporate training, online training, authoring e-learning tools, resource downloads, virtual reality, mobile learning, and outsourcing e-learning development. In the visualization of relationships between named entities, this particular CoP is characterized by (1) the recognition of members' contribution and request for feedback, (2) the use of hashtags related to e-learning development and trends, and (3) the request for career advice related to the Instructional Design profession. The study has implications for developing practitioners' pedagogical proficiencies and establishing community knowledge management and curation practices.

Keywords: Communities of Practice, Natural Language Processing, Social Media

Introduction

Tacit knowledge, or tacit knowing, was initially coined by Polanyi (1983) to describe the type of knowledge that is difficult to transfer to another person. Lave and Wenger (1991) stated that CoPs are characterized by a shared domain of interest, joint community activities, and a shared domain of practice. While present studies examine Instructional Designers' professional development needs and roles in academic and corporate settings using observation and survey methods, studies examining sources of articulated professional knowledge (explicit knowledge) in a virtual environment are required to understand current knowledge structures and gaps in Instructional Design communities. In the knowledge management literature, empirical studies in tacit knowledge extraction use n-grams and topic modeling algorithms to capture semantic relationships from explicit knowledge. The study uses natural language processing approaches, including topic modeling techniques to make topic representations and word sequences from users' posts.

Literature Review

The following literature review identifies the ways technology supports online communities of practice, the collaborative context using information and communication technologies (ICT), and the characteristics of Instructional Design communities.

Technology to Support Communities of Practice

With the advent of more collaborative ICT in Web 2.0, members in a CoP can co-produce, organize, discover, and share knowledge within a collaborative online context. Using ICT to support knowledge production and collaboration, CoPs have become increasingly virtual or Internet-mediated communities of practice. Rheingold (2000) initially coined the term virtual community to emphasize the evolution of ICT technologies and human-computer interactions that connect individuals with organizational structures. Online communities are defined as "online social networks in which people, with common interests, goals, or practices, interact to share information and knowledge, and engage in social interactions" (Chiu et al., 2006, p. 1873).

Akoumianaki (2011) argued that technologies must support virtual communities of practice regarding functional and non-functional requirements. Functional requirements are the critical pieces of technology that support members' participation and engagement. In contrast, non-functional requirements refer to the supporting technological mechanisms that enable participants to facilitate and refine their knowledge exchange. According to Heap and Kelly (2004), technical means must support the core function of knowledge creation and sharing of online communities regarding functionality, integration, usability, security, performance, reusability, and support. When these mechanisms are present in online communities, ICT tools support members in four ways; (1) ideation, information and document sharing, (2) contact management, (3) messaging and discussion, and (4) meeting and conferencing (Heap & Kelly, 2004).

As knowledge consumers, Nilan et al. (2004) stated that users in online communities try to make sense of information within a specific search context. The design of online communities can either facilitate or hinder users' movement within the community. In their findings, Nilan et al. (2004) found that members spent most of their time searching and reading within the community. Examples of searching within the community included scanning for topics or news topics, checking out other users, selecting or clicking on options, and reading within the community (e.g., reading existing content, announcements, and responding to others). The authors also reported the hindrances that users faced in virtual communities. Poorly designed interfaces hindered users' iterative searching, reading, and writing/talking within communities.

Instructional Design and E-Learning CoPs and Competencies

Schwier et al. (2004) argued that Instructional Design CoPs are born of convenience that allows informal engagement to solve specific project challenges or issues. The authors also investigated the features of Instructional Design CoPs in terms of history and culture, mutuality, plurality, knowledge repository, and tacit knowledge. They found that shared history and culture were not prominent features in Instructional Design CoPs. In contrast, passive participation as a

spectator was a critical element aligned with practitioners' agendas and community values. In terms of mutuality, community members developed their protocols for contribution and interaction with others. At the same time, community participation was based on the plurality of the intermediate relationships with other members (i.e., experts in the field) that provided a wide range of considerations and solutions to learning problems.

Due to the absence of a recognized accrediting body that identifies the required competencies for Instructional Design and Technology professionals, professional organizations have developed the competencies that define the knowledge, skills, and abilities of professionals in the field. Though several professional organizations developed their competencies, three prominent professional organizations use competencies to encapsulate the professional benchmarks, responsibilities, and capabilities of these professionals serving in different roles (e.g., Training Manager, Evaluator, Instructional Designer, and Instructional Technologist). These organizations are the American Talent Development (ATD), the International Board of Standards for Training, Performance, and Instruction (ibstpi), and the Association for Educational Communications and Technology (AECT).

Problem Statement

The characteristics of professional knowledge creation among Instructional Design CoPs in virtual environments are primarily unknown in the instructional design and technology literature. While present studies examine Instructional Designers' professional development needs and roles in academic and corporate settings, exploring sources of professional knowledge in virtual environments is required to understand the current knowledge structures and gaps in Instructional Design professional knowledge. Professional knowledge (tacit knowledge) is conveyed and shared in explicit or written form for and by community members.

Purpose & Significance of the Study

The purpose of the study is to extract tacit knowledge at the externalization stage (i.e., articulated professional knowledge) from users' written professional knowledge who are members of the Instructional Designer Facebook group. In the externalization stage articulated in the SECI model by Nonaka and Takeuchi (1995), explicit and tacit knowledge is generated, transferred, and recreated in organizations through socialization, externalization, combination, and internalization processes. The study explores the following research questions:

- **RQ 1**: What are the most frequent words and word sequences used in the CoP?
- **RQ 2**: What are the characteristics of sentiment, named entities, and relationships among entities in the CoP?
- **RQ 3**: What latent topic structures exist in the CoP?

The significance of this study involves a community's ability to manage their existing body of knowledge and leverage members' collaboration to generate new professional knowledge. CoPs act as knowledge stewarding communities where members can organize and manage a body of knowledge from which the community can draw professional learning to improve their practice. CoPs also act as a crowdsourcing mechanism where community members

can generate professional knowledge by converting tacit knowledge, or know-how experiences in the field, into explicit forms (e.g., written texts, videos).

Theoretical Framework

Research studies in the knowledge management literature examine tacit knowledge extraction from explicit forms of knowledge in the workplace (e.g., online platforms, documents, and e-mail communication). These studies are explored through the SECI model, where knowledge is continuously created through socialization, externalization, combination, and internalization phases (Nonaka & Takeuchi, 1995). First, tacit knowledge is created through a socialization process, and its tacitness is difficult to codify into explicit knowledge. Second, tacit knowledge is externalized or articulated in symbolic language for sharing with other groups or individuals. Third, the combination step requires applying and reorganizing explicit knowledge. Fourth, when explicit knowledge is applied, individuals embody the knowledge as tacit through action and reflection.

Methods

The Instructional Designer Facebook group was chosen as a data source for this study. This public Facebook group was founded in 2011 by the E-learning Industry website. According to CrowdTangle Intelligence, a public insights tool from Facebook, the Instructional Designer group is the largest public group on Facebook with 17,640 members as of September 29th, 2021 (About Us CrowdTangle, n.d.; Instructional Designer, n.d.). Any Facebook user can request access to this group by answering a filter question related to their reason for joining the group.

A total of 6,760 anonymized users' posts from August 3rd, 2017 to September 9th, 2020 were extracted with Python scripts. After cleaning Facebook posts that contained "hi," "hi there," "hello all," and "good morning professionals," the dataset was reduced to 4,717 posts. Then a sentiment analysis was performed using the Textblob Python package. (*TextBlob: Simplified Text Processing — TextBlob 0.16.0 Documentation*, n.d.). Posts were also analyzed with a variety of natural language processing tasks, including (1) n-grams with NLTK, (2) Name Entity Recognition (NER) with the spaCy Python package, and (3) topic modeling using the Latent Dirichlet Allocation algorithm (LDA) and BERT (Bidirectional Encoder Representations from Transformers) (*Linguistic Features · SpaCy Usage Documentation*, n.d.; *Natural Language Toolkit — NLTK 3.5 Documentation*, n.d.; *Open Sourcing BERT: State-of-the-Art Pre-Training for Natural Language Processing*, n.d; *NetworkX — NetworkX Documentation*, 2014). N-grams are a sequence of words that predict the probability of the occurrence of words in the corpus. NER is a natural language processing task that locates named entities in texts into eight predefined categories or tags, including geographical entity, organization, product, person, time indicator, artifact, event, and natural phenomenon.

The known limitation involved the removal of external resources placed in Facebook posts, including shared resource documents, recommended articles, and video links. While the tacit knowledge representations of these communities are static for a given period, topic models will continue to evolve as members engage in knowledge creation and sharing in their respective communities.

Findings

After cleaning Facebook posts from 6,760 to 4,717, the study results are summarized below by research question.

RQ 1: What are the most frequent words and word sequences used in the CoP?

The average word count was 38.75 words, whereas the average sentence count was 3.14 sentences in the Instructional Design Facebook Group. In Figure 1, the most frequent words included “anyone,” “id,” “course,” and “looking.” In terms of n-grams, the top three most frequently occurring bigrams were “instructional, designer,” “instructional, design,” “hi, everyone,” and “im, looking.” The top three most frequently occurring trigrams were “elearning, elearningtrends, elearningdevelopment,” “hi, everyone, im,” “instructional, design, technology,” “thanks, advance, hi,” and “would, love, hear.” As shown in Figure 2, the most frequent 4-grams were “follow, u, learningpark, learn,” “elearning, elearningtrends, elearningdevelopment, lm,” and “learnandgrow, learnfromhome, learner, learningeveryday.”

Figure 1

Instructional Designer Facebook Group Word Frequencies

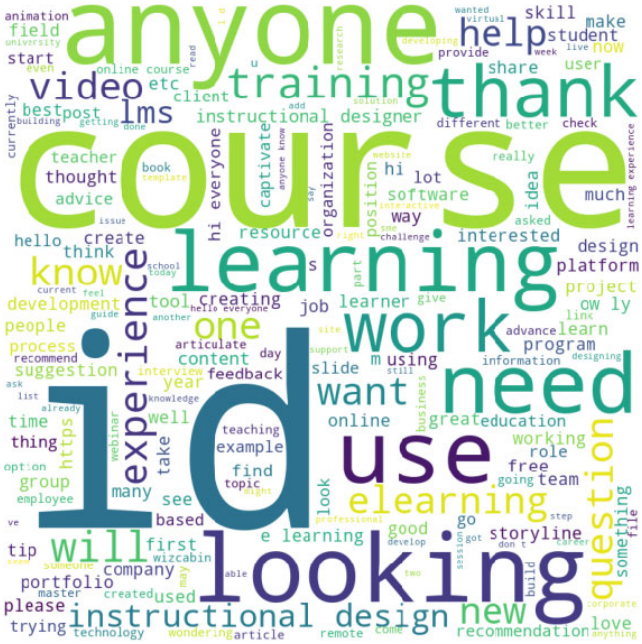
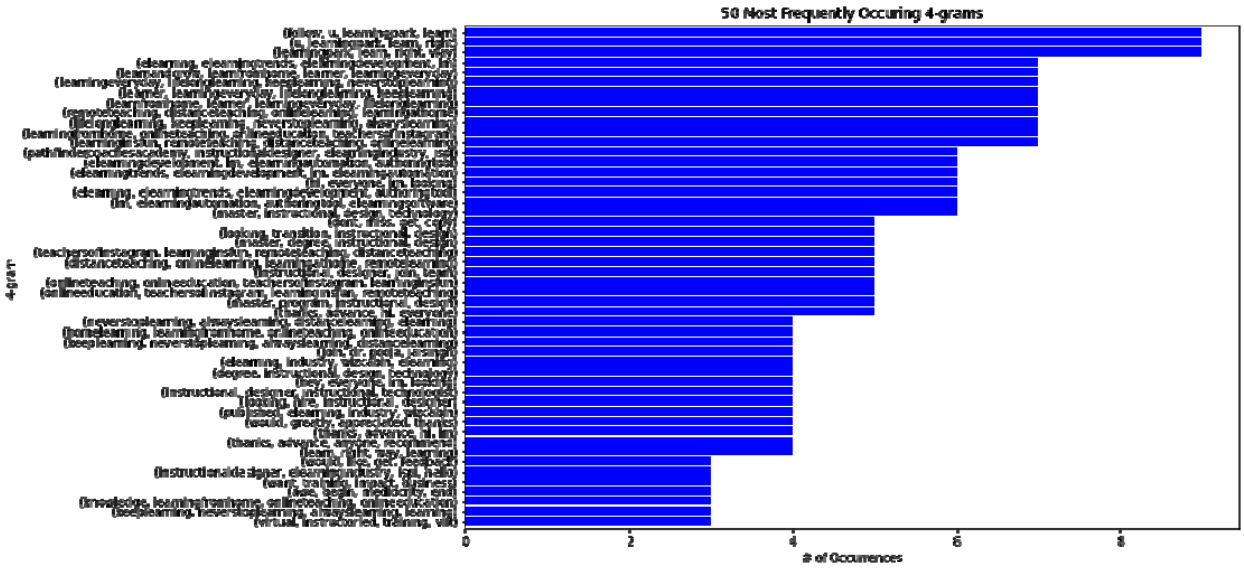


Figure 2

50 Most Frequently Occurring 4-Grams

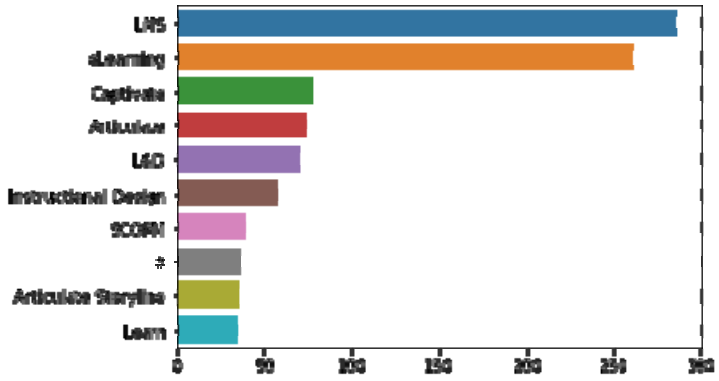


RQ 2: What are the characteristics of sentiment, named entities, and relationships among entities in the CoP?

The sentiment analysis indicated that most posts (3,298) had a positive sentiment, whereas other posts were either neutral (1,011) or negative (408) sentiment. In terms of recognized named entities, most entities were related to the organization entity. In Figure 3, most organizational entities were related to LMS, elearning, Captivate, and Articulate. The limitation of NER involved the lack of differentiation between entity types related to organization, product, person, and country or nationality entities. For example, NER assigned person and nationality entities to web conferencing tools, authoring software, and learning management systems. In terms of product entities, shared resources (e.g., e-books) were also recognized in the community. The entity relationships with the highest degree included "educational, animation," "instructional designer, e-learning industry," "responsive e-learning design, multidevice," and "just for fun, effective learners."

Figure 3

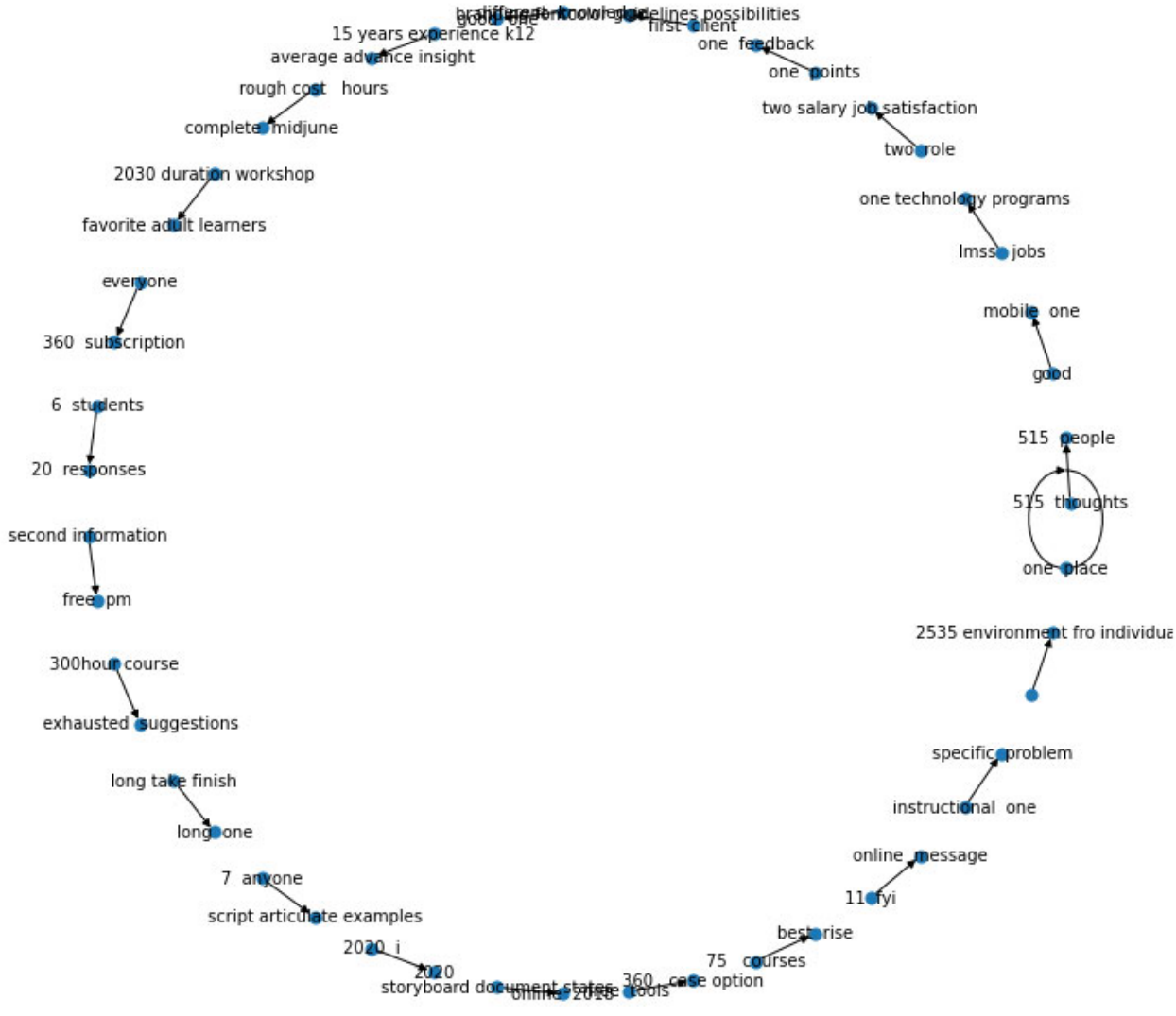
Most Frequently Recognized Entity Types



The most popular entities included “one” and “today,” whereas the most popular target entities had “good one” and “https.” The most popular relationships among entities were “thanks,” “thank” and “want.” When visualizing “thanks” as a popular relationship, as shown in Figure 4, members in this CoP appeared to engage with each other’s requests related to various topics, including resource sharing, Instructional Design graduate programs, and e-learning authoring software and hardware.

Figure 4

Most Popular Relationships for “Thanks” Entity



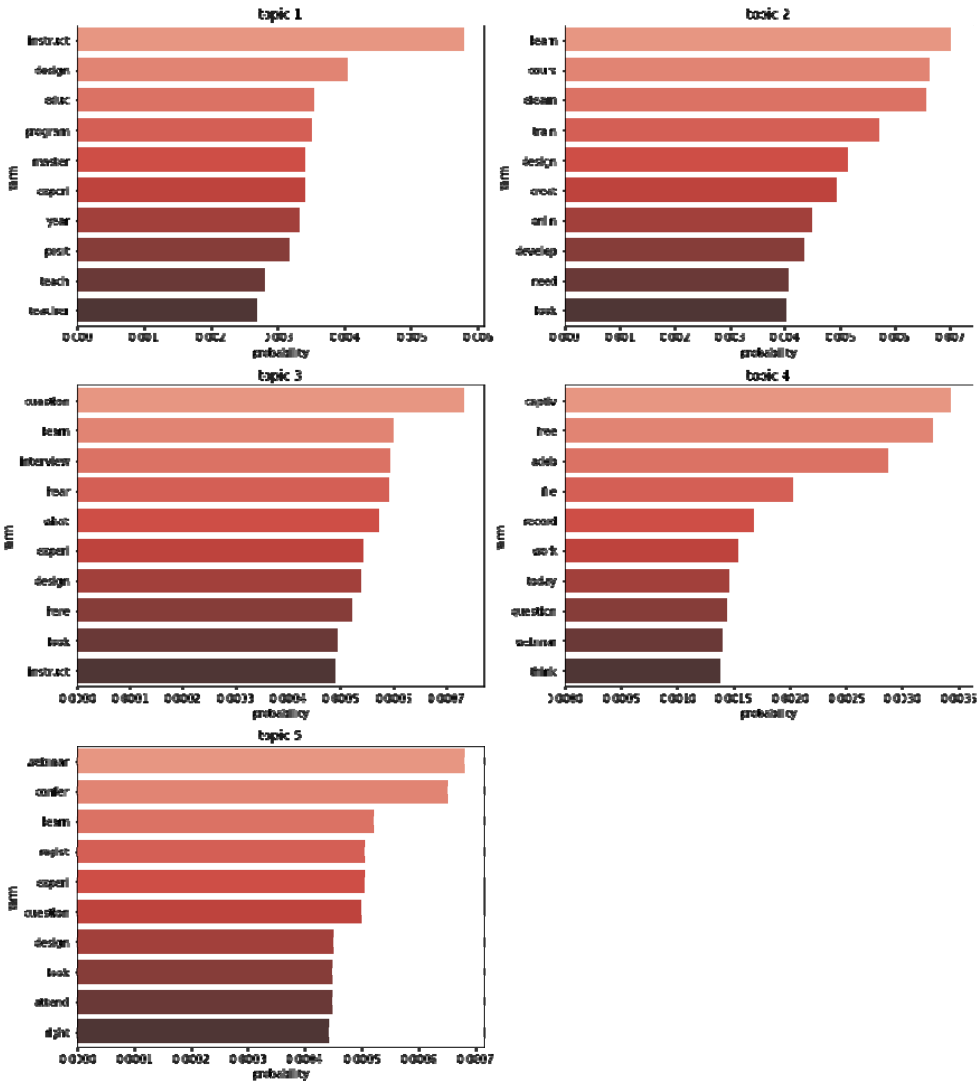
RQ 3: What latent topic structures exist in the CoP?

The bag-of-words, TF-IDF, and sentence embeddings topic models were developed to identify latent topics from the Facebook group. After obtaining the highest semantic coherence of 0.48 using five topics for the LDA algorithm topic parameter, as shown in Figure 5, the five topics in the bag-of-words and TF-IDF models had a similar distribution of topics related to:

1. Instructional Design job postings
2. Learner or student online training
3. Asking for advice related to e-learning authoring tools
4. Online course and video development
5. Sharing of webinar events

Figure 5

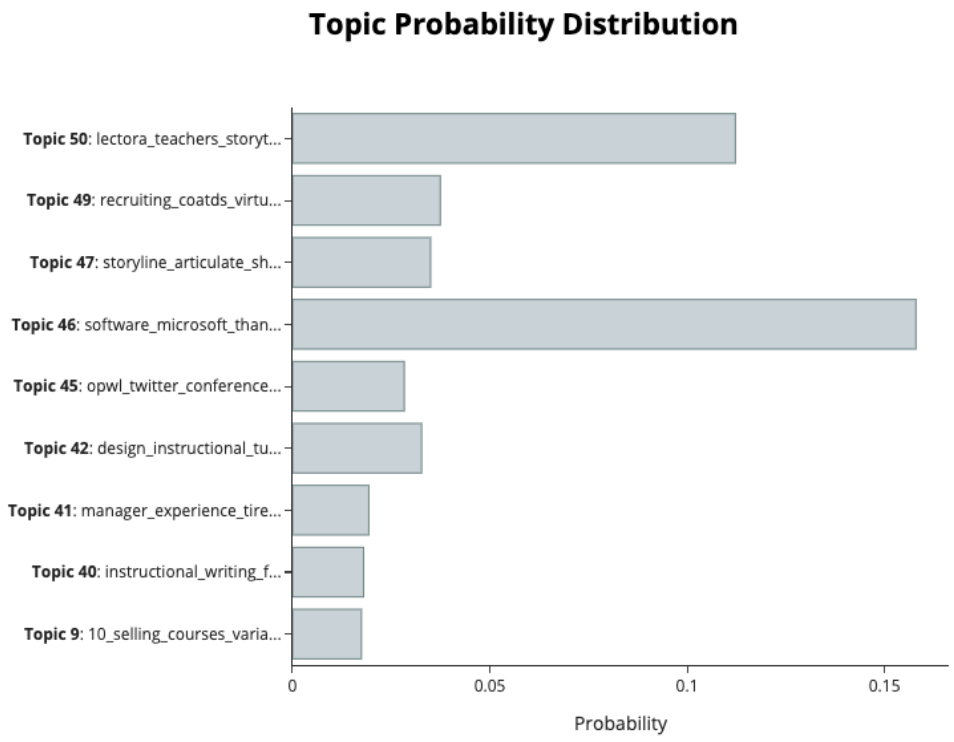
TF-IDF Model Topic Distribution



In the last model using sentence embeddings with BERT, the model automatically performed a dimensionality reduction and clustering of texts. Based on the intertopic distance map, the 74 topics were present in nine clusters. In Figure 6, the nine topics with the highest probability were as follows: (1) Microsoft products, (2) lectora and storyline e-learning authoring, (3) virtual recruiting, (4) story articulate, (5) conferences, (6) Instructional Design, (7) managerial/trainer jobs, (8) instructional writing, and (9) selling online courses.

Figure 6

BERT Topic Probability Distribution



Discussion

In the analysis of 4,717 users' posts from the Instructional Designer Facebook group, the average sentence word count was 38.75 words, and the average sentence count was 3.14 sentences. In terms of sentiment, 3,298 posts were positive, 1,011 posts were neutral, and 408 posts were negative. Words with the most frequency included: "id," "course," "learning," "anyone," and "looking." The most frequent 4-grams were "follow, u, learningpark, learn," "elearning, elearningtrends, elearningdevelopment, lm," and "learnandgrow, learnfromhome, learner, learningeveryday." The entity relationships with the highest degree included "educational, animation," "instructional designer, e-learning industry," "responsive e-learning design, multidevice," and "just for fun, effective learners."

In this particular CoP, there was an emphasis on learning management systems that support various tasks, including task management, employee onboarding, and compliance

training. Based on the observed n-gram sequences and entities, the Facebook group posts appeared to suggest three aspects of knowledge sharing among members:

1. Recognizing members' contributions and requests for feedback through informal salutations and following certain users and posts
2. Using hashtags related to e-learning development and trends for resharing and following
3. Requesting career advice related to transitioning to the Instructional Design field

Although topic representations in the bag-of-words and TF-IDF topic models were almost identical using the LDA algorithm, LDA relied on semantic similarities based on words rather than the context of the words. To compensate for the shortcomings of LDA, BERT allowed for discovering subtopics and topic outliers based on the context of the surrounding words. In the BERT topic model, nine topics were prominent in the Facebook group, including (1) Microsoft products, (2) lectora and storyline e-learning authoring, (3) virtual recruiting, (4) story articulate, (5) conferences, (6) Instructional Design, (7) managerial/trainer jobs, (8) instructional writing, and (9) selling online courses.

Implications & Future Research

The empirical evidence of tacit knowledge structures informs researchers and practitioners about the present capabilities and strengths of CoPs in producing and sharing knowledge in certain areas of Instructional Design expertise. Other research can build on new ways of creating and supporting new tacit knowledge production in virtual CoPs by experimenting with content curation practices, knowledge discovery mechanisms, repository tools, and social knowledge representation methods described by Cagliero and Fiori (2012) (e.g., subject-based classification, folksonomy, and structured knowledge). It is recommended that Instructional Design CoPs adopt a taxonomy or classification system based on professional competencies to organize existing professional knowledge and improve knowledge discovery within the community. Even though the primary function of this CoP is to support educational technology needs, building pedagogical proficiencies in Learning Sciences, Instructional Design, and Knowledge Management is also essential for practitioners' professional development.

Conclusion

The resulting study contributes to understanding the knowledge production capabilities and shared practices in Instructional Design CoPs. After analyzing 4,717 anonymized posts from a public Facebook group in Instructional Design, popular word frequencies and n-grams were related to asking peers and looking for solutions. While named entities were related to learning management systems and e-learning tools, the network visualization of these entities showed active engagement in seeking advice related to resources, Instructional Design graduate programs, and software tools.

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Visualizing Google and YouTube Search Trends for COVID-19, Instructional Design, and Remote Learning

Javier Leung, PhD Candidate
School of Information Science & Learning Technologies
College of Education & Human Development
University of Missouri

611 Conley Ave, Columbia, MO (USA)
leungj@missouri.edu or javier.leung81@gmail.com

Abstract

As educational institutions switched from in-person to Remote Learning or Emergency Remote Teaching (ERT), this study explores the search popularity indices of three search terms globally and in the USA from January 2020 - April 2021. Google search terms, such as *COVID-19*, *Instructional Design,* and *Remote Learning*, showed considerable search interest in Google Trends at the peak of the pandemic on Mach 11, 2020 (WHO, 2020). Pytrends was used to extract search interest of the primary and related terms from Google and YouTube Search globally and in the USA (Pytrends, n.d.). The search interest of the three search terms and associated terms exhibited similar peaks and dips of interest at the beginning of the pandemic and the 2020-2021 school year. Educational technology tools, including *SeeSaw Learning* and *Zoom,* were present as related search terms for *Remote Learning*. Search queries in YouTube revealed educational channels that host various lecture materials related to K-12 and professional development. The interactive visualizations in Tableau Public enable users to explore the search trend patterns of the three main terms and related queries. This project serves as an archive of users' conscious information seeking to highlight the pivotal roles of Instructional Design and Remote Learning observed in search popularity indices in light of the pandemic. The project can be accessed at edtechtrends.javierleung.com or on Tableau Public (Leung, n.d-a, n.d.-b).

Keywords: Instructional Design, Remote Learning, COVID-19

Introduction

The World Health Organization (WHO) declared the novel coronavirus (COVID-19) outbreak a global pandemic on March 11th, 2020 (WHO, 2020). Since the beginning of the pandemic, 1.3 billion learners are still affected by the school, and university closures as institutions implement entirely online and hybrid solutions (UNESCO, 2020). As instructors in higher education and K-12 adapt their face-to-face curricula to distance delivery formats, the role of Instructional Design and Technology has been a critical element in creating equitable access to learning experiences for all kinds of learners.

This study reports on a data visualization project of global and USA search trends related to *Instructional Design, Remote Learning,* and *COVID-19* before the pandemic and at the peak of the pandemic across Google and YouTube Search. This project explores popularity indices in a single interactive interface using Tableau Public by querying the Google Trends API. The

project also enables users to explore search popularity indices of multiple search terms over time from January 2020 through April 2021. In these visualizations, the audience can interact with the search popularity indices for trending searches and related queries for three search terms (i.e., *Instructional Design, Remote Learning,* and *COVID-19*). Although Google Trends provides a way for exploring the popularity index (0% - 100% being the most popular) of an individual search term for the past 12 months or since 2004 for specific search terms, the interface of Google Trends does not allow for exploration of multiple related terms. This project provides a better understanding of the pivotal role of Instructional Design, Remote Learning, educational technology tools in the context of the COVID-19 popularity index.

Literature Review

The following literature review is divided into two sections. The first section describes the needs of educators in ERT during the COVID-19 pandemic. The second section describes the applications of Google Trends in academic and clinical research.

Emergency Remote Teaching and Learning

During the Spring of 2020, K-12 schools and institutions of higher education moved face-to-face classes to online formats to prevent the spread of the virus that causes COVID-19. As the 2020-2021 school year has progressed, schools have faced the difficult transition to emergency remote teaching (ERT) while keeping students, faculty, and staff safe. Hodges et al. (2020) clearly defined the differences between ERT and online learning. ERT is the shift of instructional delivery to alternate delivery modes due to crisis circumstances. In contrast, online learning involves design decisions for effective online learning based on Instructional Design choices that generally require six to nine months before the course is delivered (Hodges et al., 2020). Furthermore, Barbour et al. (2020) identified the four phases of educational institutions responding to the COVID-19 pandemic. The first phase involved a rapid transition to remote teaching and learning where the health and safety of students and educators were the most critical aspect while transitioning course materials to synchronous (e.g., video over Zoom or WebEx) and asynchronous (e.g., Google Slides and VoiceThread) online formats in four weeks. The second phase required ERT to include essential components, including (1) course navigation, (2) equitable access, (3) student support mechanisms, and (4) academic integrity. As face-to-face courses were transitioned to ERT with acceptable mechanisms for delivering quality learning experiences, the third phase involved careful planning in supporting students and educators for a full term for online delivery. In the fourth phase, K-12 schools and institutions of higher education had new levels of online learning infrastructure to support students and educators.

Supporting the Needs of Educators

Recent studies have identified the needs and challenges of educators (e.g., faculty in higher education) and staff (e.g., Instructional Designers and Technologists) in delivering ERT to students and supporting the professional development needs of educators in the light of the ongoing global COVID-19 pandemic. Redstone and Luo (2021) reported the types of professional development (e.g., teaching, community, and organization support) that instructors

in higher education needed during ERT. Their principal findings included a centralized information hub for resources to support ERT transition and community support for self-directed and peer-to-peer social activities (Redstone & Luo, 2021). Also, Vollbrecht et al. (2021) identified design considerations for ERT delivery. Seven suggestions include (1) considering learners in different time zones, (2) team-based teaching in synchronous sessions, (3) increasing faculty availability for student questions, (4) providing specific time for troubleshooting technical difficulties and classroom breaks in synchronous sessions, (5) providing several learning opportunities in both synchronous and asynchronous formats, (6) considering the well-being of students and educators, and (7) findings ways to engage students virtually.

Google Trends for Research

Google Trends is widely used to complement traditional academic and clinical research to predict or forecast outcomes (e.g., economic activity, disease tracking, and user's search behavior) in a given geographical area (Levinthal, 2021). In epidemiology, several studies using Google Trends data helped predict the spread of respiratory diseases in geographic regions of interest (Polgreen et al., 2008; Brownstein et al., 2009; Valdivia & Monge-Corella, 2010; Mavragani & Gkillas, 2020). Google Trends can also be used as a surveillance system to detect disease outbreaks. For example, Carneiro and Mylonakis (2009) argued that Google Trends could detect regional influence outbreaks 7-10 days before conventional surveillance systems used at the Centers for Disease Control and Prevention. In economics, Google Trends is used to predict several economic metrics, including unemployment claims in the US, Germany, and Israel (Choi & Varian 2009; Askitas & Zimmermann, 2010) and consumer and consumption sentiment (Huang & Penna, 2009; Schmidt & Vosen, 2009).

Problem Statement

The COVID-19 crisis brought immense challenges to educators and instructional staff around the globe. It is hypothesized that Instructional Design, Remote Learning, educational technology tools are critical knowledge and skills for ERT delivery. Therefore, Google and YouTube searches should reflect users' information needs, especially at the beginning of the pandemic and the 2020-2021 school year.

While models of information behavior exist to explain why users seek information, this exploratory study does not adhere to a specific information behavior model due to various users' motivations, needs, and their roles in the search, and possibly avoidance, of information. Despite the lack of generalizability of information behavior captured in Google Trends, Case and Given (2016) identified the agreed-upon terminology in the information behavior literature, including information need, information seeking, and information behavior. An information need refers to the inadequate knowledge that users have. Information seeking is the conscious effort to acquire knowledge in response to the need or gap. Information behavior is complex and encompasses both conscious and unconscious information seeking, encountering, or avoidance.

Purpose & Significance of the Study

The purpose of this study is two-fold. First, this study explores the popularity indices of *COVID-19, Instructional Design, and Remote Learning* as the primary search terms from Google and YouTube Search from January 2020 - April 2021 globally and in the United States. Second, the study seeks to identify the peaks and dips of user search interest in light of the COVID-19 pandemic. The study explores the following research questions:

- **RQ 1**: What are the related search terms for *COVID-19, Instructional Design,* and *Remote Learning* from Google Search and YouTube Search globally and in the USA?
- **RQ 2**: What are the peaks and dips in popularity indices for *COVID-19, Instructional Design,* and *Remote Learning* from Google Search and YouTube Search globally and in the USA?

The study's findings allow for an exploration of search interest for knowledge in Instructional Design, Remote Learning, and educational technology tools to support the transition from face-to-face to the ERT format as educational institutions grapple with the pandemic. The following section describes the extraction methods and visualization components.

Methods

The Python Pytrends package was used to connect to the Google Trends API to extract search popularity indices of three keyword searches, *COVID-19*, *Instructional Design*, and *Remote Learning,* from Google Search and YouTube Search (*Pytrends*, n.d.). These search trend reports identify the normalized search volume of keywords and topics by state or province, country, and continent. Although Google Trends data does not indicate the real-time volume of searches, the data is normalized from 0 -100 to describe the search interest of topics (i.e., 0 being the lowest and 100 being the maximum peak of interest) for the past five years or 2004 for specific search terms (*FAQ about Google Trends Data - Trends Help*, n.d.).

For this particular study, the *TrendReq*, *Interest Over Time*, and *Related Queries* methods in the Pytrends Python package were implemented to automate the download of search trend reports from Google Search and YouTube Search from January 2020 - April 2021. Each report described the popularity indices of the keywords mentioned for the United States and globally. To further identify the related search term queries for *COVID-19*, *Instructional Design*, and *Remote Learning,* the *Related Queries* method in Pytrends allowed the extraction of the search trend data of related queries. Five known limitations of this study involved the following:

1. Filtering certain search terms
2. Extracting top search terms over rising search terms
3. Eliminating related and repeated main search terms and their variations that do not align with the context of Instructional Design and Remote Learning
4. Censorship of Google and YouTube in certain countries
5. Global search volume can be skewed

First, Google Trends filters certain types of searches, including searches with a volume of *0* or very few searches made by few people, duplicate searches, or repeated searches from the same person over a short period, and searches with special characters that use apostrophes and other special characters. Second, Google Trends allows extracting top and rising searches. While top searches are the terms with the most frequency, rising searches are the terms that have had significant growth over time. For this particular study, rising terms were not considered because of the changing nature of search volume growth. Unlike rising terms, top searches reflected the real search interest of individuals in the USA and globally. Third, the visualizations did not include related and repeated main search terms, including *breathing exercises covid-19, covid-19 vaccine, instructional materials design,* and *instructional design jobs*. However, the terms above are included in Tables 2 and 3. Fourth, certain countries do not allow access to Google and YouTube. Crimea, Cuba, Iran, North Korea, and Syria do not allow access to Google services (*Countries or Regions Where Google Workspace Is Available - Google Workspace Admin Help*, n.d.). China, Eritrea, Iran, North Korea, Sudan, South Sudan, Syria, Tajikistan, and Turkmenistan do not allow access to YouTube services (Wikipedia contributors, n.d.). Fifth, there is a possibility that search index volume from Google and YouTube Search can be skewed based on a country's search volume. For example, the majority of search volume may come from the USA and India for global search trends. For this study, the global search index includes the United States and other countries, excluding countries where Google and YouTube are banned.

Two datasets were assembled to represent the popularity indices of various search terms to describe the search trends for the primary keyword searches and related terms in the United States and globally. Each dataset was subsequently visualized on a weekly basis in Tableau Desktop. Even though trend reports are insightful in understanding the peaks and dips of search interest of specific terms, the COVID-19 pandemic adds a vital context related to the information seeking of users in understanding the need for information in Instructional Design and Remote Learning. The design of the Tableau dashboards involved following six fundamental principles of information design by Tufte (1983), including comparison, causality, multivariate, integration, documentation, and context. Each Tableau dashboard is contextualized around COVID-19 milestones and news related to vaccine development by the World Health Organization (WHO), U.S. Food Drug and Administration (FDA), United Nations (UN), and National Institutes of Health (NIH). These important milestones are annotated in the search trend data for the *COVID-19* term along with its respective search popularity index. While the beginning of the 2020-2021 school year varies in the USA, the school year was annotated on August 1st, 2020. A summary of milestones and indices is depicted in Table 1.

Table 1

Summary of Milestones and Search Popularity of Main Terms by Google and YouTube Search

Date	Milestone	Global COVID19 Index	USA COVID/ COVID19 Index	Global Instructional Design Index	USA Instructional Design Index	Global Remote Learning Index	USA Remote Learning Index
03/11/2020	**Milestone 1:** WHO declares COVID-19 a pandemic	Google 86 YouTube 67	Google (Covid) 100 YouTube (Covid19)	Google 37 YouTube 57	Google 51 YouTube 51	Google 100 YouTube 63	Google 63 YouTube 63

			19				
06/26/2020	WHO announces 2 billion doses of COVID-19 vaccine	Google 11 YouTube 12	Google (Covid) 82 YouTube (Covid19) 12	Google 76 YouTube 76	Google 69 YouTube 69	Google 17 YouTube 69	Google 71 YouTube 21
07/27/2020	Phase 3 clinical trial of an investigational vaccine for COVID-19 begin	Google 12 YouTube 11	Google (Covid) 73 YouTube (Covid19) 11	Google 79 YouTube 71	Google 87 YouTube 79	Google 60 YouTube 60	Google 73 YouTube 60
08/01/2020	**Milestone 2:** Beginning of 2020 school year (USA)	Google 75 YouTube 7	Google (Covid) 63 YouTube (Covid19) 7	Google 84 YouTube 84	Google 71 YouTube 71	Google 79 YouTube 79	Google 88 YouTube 79
12/18/2020	**Milestone 3:** FDA grants emergency use authorization to Pfizer and BioTech's coronavirus vaccine	Google 59 YouTube 35	Google (Covid) 85 YouTube (Covid19) 35	Google 30 YouTube 46	Google 51 YouTube 46	Google 100 YouTube 10	Google 30 YouTube 19
02/27/2021	**Milestone 4:** FDA grants emergency use authorization to J&J 's Covid-19 vaccine	Google 35 YouTube 6	Google (Covid) 67 YouTube (Covid19) 6	Google 60 YouTube 60	Google 13 YouTube 60	Google 10 YouTube 15	Google 16 YouTube 15
04/20/2021	**Milestone 5:** Global tally of deaths from Covid-19 surpasses 3 million	Google 19 YouTube 32	Google (Covid) 53 YouTube (Covid19) 32	Google 42 YouTube 42	Google 38 YouTube 42	Google 10 YouTube 10	Google 8 YouTube 14

Four Tableau dashboards were published to identify Google and YouTube search trends globally and in the United States for *COVID-19, Instructional Design,* and *Remote Learning.* The terms *Instructional Design, Remote Learning,* and *COVID-19* are selected by default in the dashboards. Also, the terms of interest contained annotations of the selected terms with their respective peaks of search interest and their average popularity indices. Multiple terms can be selected and highlighted using the selection menu to compare search trend data further. As search terms are chosen, the terms are color-coded with their respective labels on the trend chart. To better navigate the charts, it is recommended to view the dashboards in full-screen mode.

Findings and Discussion

It is essential to point out that *Covid19* had more peaks in Google Search globally than *Covid-19*. In the United States, *covid* was more prominent than other term variations (e.g.,

Covid-19, Covid 19, and Covid19) in Google Search. In the United States, *Covid* was the primary search term in Google Search, whereas *Covid19* was the prevalent search term in YouTube Search. Interestingly, the term *Emergency Remote Teaching* and its variations (e.g., *ERT, Emergency Remote Learning, and Emergency Remote Teaching and Learning*) did not appear as related terms to *Instructional Design* or *Remote Learning*. It seems that users were more acquainted with *Remote Learning* and associated educational technology tools.

RQ 1: What are the related search terms for *COVID-19, Instructional Design,* and *Remote Learning* from Google Search and YouTube Search globally and in the USA?

For *COVID-19*, the related terms included *Covid19* for global Google Search and *Covid* for USA Google Search. Also, related search terms (i.e., cases, deaths, news, symptoms, and testing) to *Covid19* were prevalent in Google Search in the United States. Related combinations such as *Instructional Design + Remote Learning* were present in both global and USA Google Search. *Remote Learning* also contained related terms, including *E-Learning + Remote Learning* in global Google Search and *covid19 + remote learning* in the USA Google Search.

Interestingly, related terms to *Remote Learning* in global Google Search included an educational technology provider (i.e., *Seesaw Remote Learning*) and a web conferencing tool (i.e., *Zoom*). Seesaw Remote Learning is an online classroom app that delivers asynchronous and synchronous learning with feature-rich communication and class management tools. In addition, Seesaw provides integration of Google Classroom and support of BYOD (i.e., Bring Your Own Device) to allow students' personal devices with access to school resources (*Seesaw*, n.d.). Zoom is better suited for synchronous remote and hybrid learning as a web conferencing tool for teaching and learning. Zoom also supports a variety of engagement strategies, including formative strategies (e.g., quizzes and surveys) and brainstorming activities (e.g., breakout rooms, screen sharing, and interactive whiteboard) (*Zoom for Education*, n.d.). Table 2 summarizes the related terms or queries for the search terms of interest (*COVID-19, Instructional Design,* and *Remote Learning*) from Global and USA Google Search.

Table 2

Related Search Terms for Global and USA Google Search

COVID-19		***Instructional Design***		***Remote Learning***	
Global	**USA**	**Global**	**USA**	**Global**	**USA**
Covid-19 *Covid19* *covid19 + remote learning*	*Covid* *Covid 19* *Covid-19* *Covid19* *Vaccine* *Covid19 Cases* *Covid19 Deaths* *Covid19 News* *Covid Symptoms* *Covid19 Us* *Covid19 Testing*	*Instructional Design* *Instructional Design + Remote Learning*	*Instructional Design* *Instructional Design + Remote Learning*	*E-Learning + Remote Learning* *Elearning + Remote Learning* *Zoom* *Seesaw Remote Learning* *School Remote Learning*	*Doe Remote Learning* *Zoom* *Seesaw Remote Learning* *Zoom Remote Learning* *Zoom For Remote Learning* *What is Remote Learning* *Remote Learning Tips* *Remote Learning Setup* *Remote Learning Fall 2020*

					remote learning *covid19 + remote learning*

For the term *Covid-19*, the related terms were variations of the search term (*covid* and *covid 19*), *covid-19 vaccine*, and *covid-19 + remote learning* in global Youtube Search. In contrast, in USA YouTube Search, related terms were *covid* and *breathing exercises covid-19*. In terms of *Instructional Design* in global YouTube Search, related terms were related to the design of instructional materials and jobs in Instructional Design. However, related terms to *Instructional Design* were not present in the USA YouTube Search. For *Remote Learning* in global YouTube Search, three related terms were related to *covid* and two YouTube channels that host free educational content, including Vidura and Gours. Vidura eLearning is based in Sri Lanka with approximately 19,000 subscribers and provides educational content from grades 1 through 5 (*Vidura eLearning*, n.d.). Gours eLearning is based in India with about 52,000 subscribers and offers financial education and certification resources in online instructor-led and self-paced formats (*Gour's e-Learning*, n.d.). Table 3 summarizes the related terms or queries for the primary key search terms (*COVID-19, Instructional Design,* and *Remote Learning*) from Global and USA YouTube Search.

Table 3

Related Search Terms for Global and USA YouTube Search

COVID-19		***Instructional Design***		***Remote Learning***	
Global	**USA**	**Global**	**USA**	**Global**	**USA**
covid *covid-19 vaccine* *covid 19* *covid-19 + remote learning*	*covid* *breathing exercises covid-19*	*instructional materials design* *instructional design jobs*	N/A	*covid* *vidura elearning* *gours elearning*	N/A

RQ 2: What are the peaks and dips in popularity indices for *COVID-19, Instructional Design,* and *Remote Learning* from Google Search and YouTube Search globally and in the USA?

A total of ten findings were found in comparing popularity search indices for Google and YouTube Search in the United States and globally. Overall, this study's terms of interest and related terms exhibited similar peaks and dips of search interest at the start of the pandemic in March 2020 and the 2020-2021 school year. The section below highlights the findings by global and USA Google Search and YouTube Search.

Global Google Search

Finding #1. The search term *Covid19* had more peaks than *Covid-19*. *Covid19* received more search interest than *Covid-19* in Google Search globally.

Finding #2. The search terms *Covid19, E-Learning + Remote Learning, Elearning + Remote Learning, Instructional Design + Remote Learning,* and *Remote Learning Fall 2020* exhibited similar peaks of interest in Google Search globally.

Finding #3. *Remote Learning* had two significant peaks of interest at the beginning of the pandemic and the 2020-2021 school year, followed by a downward trend in Google Search globally.

USA Google Search

Finding #4. The term *Covid* was the most prominent with an upward trend than any other variation of the term (*Covid-19, Covid 19, and Covid19)* in USA Google Search.

Finding #5. The term *Instructional Design* was at its highest peak (100) on July 12th, 2020. Then it levelled off in 2021 with search interest approximately at 65 in USA Google Search. *Instructional Design* remained independent of the pandemic's peaks of interest for *Covid* and its related terms.

Finding #6. The terms *Covid* and *Remote Learning* terms exhibited similar peaks of interest at the beginning of the pandemic and the 2020-2021 school year. About *Covid*, *Remote Learning* was at its highest after 18 days of the beginning of the pandemic and after 32 days at the beginning of the school year in August 2020. After October 2020, the *Remote Learning* term experienced a drastic downward trend by the end of 2020 and the beginning of 2021. It would be possible that public and private institutions have leveraged educational technologies to deliver learning in online and hybrid formats at the beginning of the Fall of 2020.

Global YouTube Search

Finding #7. The terms *E-Learning + Remote Learning, Elearning + Remote Learning, Remote Learning,* and *remote learning* had similar peaks and dips search interest in YouTube Search globally.

Finding #8. *Remote Learning*, *remote learning,* and *Instructional Design + Remote Learning* experienced two significant peaks at the height of the pandemic and the 2020-2021 school year, followed by a downward trend in early 2021. Global YouTube Search interest for *Instructional Design* did not seem to show significant peaks and dips in 2020 and early in 2021.

USA YouTube Search

Finding #9. In the USA YouTube Search, *Zoom, Zoom Remote Learning, Covid19, Covid-19, Instructional Design + Remote Learning,* and *covid19 + remote learning* exhibited significant peaks at the beginning of the pandemic in March 2020 and the 2020-2021 school year in August 2020.

Finding #10. In the USA YouTube Search, *Instructional Design + Remote Learning* and *Zoom* showed similar search interest with peaks of interest at the beginning of the pandemic and

2020-2021 school year. However, *Instructional Design* exhibited no significant peaks or dips in search interest on YouTube and experienced two significant peaks (100% interest) on July 12th and September 20th, 2020.

Implications & Future Research

The study presents implications for practice and research. The significance for practitioners involves bringing awareness of centralized information hubs to help educators and students transition to ERT and establishing communication plans for resource-sharing among Instructional Designers and Technologists who support educators' professional development. The implication for researchers identifies the need to study the main search terms and their related queries to understand users' information seeking and needs in emergency situations. Research can also focus on anticipating information seeking by exploring upward and downward trends in search queries.

Conclusion

This study accomplishes two goals: (1) keeping an archive of information seeking from search engines and (2) highlighting the search interest of Instructional Design, Remote Learning, and educational technology globally and in the USA across Google and YouTube Search from January 2020 - April 2021. The search term *Remote Learning* and *Covid* had similar peaks of search interest in USA Google Search at the beginning of the pandemic in March 2020 and the 2020-2021 school year. In USA Google Search, the highest peak for *Remote Learning* occurred 18 days after the highest peak for *Covid*, and 32 days after the beginning of the school year, given the assumption that the school year began in the first week of August.

The search term variations of the *COVID-19* terms were C*ovid-19, Covid19,* and *covid19 + remote learning* in global Google Search. Related terms to *COVID-19* included *Covid19, Covid19 Cases, Covid19 Deaths, Covid19 News, Covid Symptoms, Covid19 US,* and *Covid19 Testing* in USA Google Search. Related terms to *Instructional Design* were *Instructional Design + Remote Learning* in USA Google Search. Associated terms for *Remote Learning* showed educational technologies (e.g., *Zoom, SeeSaw, Remote Learning Setup,* and *E-Learning*) in global and USA Google Search. In USA Google Search, related terms to *Remote Learning* included governmental guidance (e.g., *Doe Remote Learning*) at the beginning of the 2020-2021 school year.

The related search terms for *COVID-19* were *vaccine* and *remote learning* in global YouTube Search, whereas *breathing exercises covid-19* was present in USA YouTube Search. *Instructional Design* did not have any related terms to *COVID-19* and *Remote Learning* in global and USA YouTube Search, except for *instructional materials design* and *instructional design jobs*. In global YouTube search, related terms to *Remote Learning* included educational channels that target K-12 students and professional development resources. However, no associated terms for *Remote Learning* were present in USA YouTube Search.

As educational institutions face last-minute adaptations of face-to-face curricula to online and hybrid formats, the COVID-19 pandemic has accelerated the need for knowledge related to Instructional Design, Remote Learning, and educational technology tools.

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Intelligent Classroom Teaching Behavior Analysis System Based on S-T Analysis Method

Jiaxuan Li
Department of Education Information Technology, East China Normal University
Shanghai, China
15201703716@163.com

Yaofeng Xue
Department of Education Information Technology, East China Normal University
Shanghai, China
yaofeng.xue@163.com

Abstract: Compared with traditional classroom teaching observation, the classroom behavior analysis system using information technologies can effectively improve the validity and accuracy of interpretation of classroom teaching behaviors. With the development of information technology, the combination of the application of teaching methods and artificial intelligence has become an inevitable trend. Based on the S-T teaching behavior analysis method, an intelligent classroom teaching behavior analysis system using multi-modal recognition technology was proposed, which applied various information technologies to collect classroom teaching behavior data and code them automatically. The accuracy and reliability of the presented system was verified through the collection and analysis of a large number of classroom behavior data, which provided a valuable scientific analysis tool for classroom teaching behavior research.
Keywords: Classroom teaching behavior analysis, S-T analysis method, Multi-modal recognition technology

1 Introduction

Today, as education informatization is gradually deepening, the theory of teaching and learning continues to develop. Gradually integrate new educational concepts and technical means into classroom teaching, and traditional teaching evaluation methods have gradually failed to meet the needs of teaching development. Classroom teaching evaluation methods need to keep pace with the times, classroom teaching practice calls for in-depth study of classroom teaching behavior (Taut & Sun, 2014). This study completed an intelligent analysis system based on S-T analysis method and multi-modal recognition technology, and verified its accuracy and reliability. This not only provides a basis for teachers to improve teaching content and teaching methods, but also has great significance for promoting the development of teachers' professional ability.

2 Literature Review

2.1 the S-T Analysis Method

The advantages and disadvantages of classroom teaching are largely related to the interaction between teachers and students. Classroom is the main place where teaching activities take place. Classroom behavior takes place in this space and the information transmission between teachers and students interacts and interacts in this space. As the main body of the teaching process, the

behavior of students in the classroom can directly reflect their learning status. As a guide for students to learn, teachers also play an important role in guiding behavior. Therefore, analysis of classroom teacher and student behavior is conducive to analyzing classroom teaching process. Some scholars have been working on software for collecting and analyzing classroom teaching behavior data and have made good progress (Yun et al. , 2018). Some scholars have conducted classroom observations from multiple angles and at multiple levels, and also provided new ideas for data collection and processing of this study (Xie & Cao, 2010). Japanese scholars first proposed the S-T teaching analysis method for classroom teaching analysis. S-T analysis method is the Student-Teacher analysis method, which is a teaching analysis method that visually expresses the teaching personality in a graphical way (Jun & Ou, 2011). The main steps of the method are divided into data sampling, analysis of time series data, drawing S-T diagram, and drawing RT-CH diagram to judge the teaching mode analysis. In the actual classroom teaching process, the specific manifestations of Teacher's behavior and Student's behavior are shown in Table 1. Since the Student's behavior includes all behaviors other than the Teacher's behavior, in addition to the 11 behaviors described in Table 1, it can be classified as "Others" as a form of Student's behavior.

Table 1: Specific manifestation of T behavior and S behavior

Category	Number	Manifestations	Category	Number	Manifestations
Teacher's behavior	1	explanation	Student's behavior	7	Student's speech
	2	demonstration		8	Student's thinking, calculation
	3	blackboard		9	Student taking notes
	4	using various media to prompt		10	Doing experiments or finishing homework
	5	question and name		11	Keeping silence
	6	evaluation and feedback		12	Others

This study draws on the traditional classroom teaching behavior analysis method, and uses a variety of information technologies to collect and analyze classroom teaching behaviors. It will record actual classroom teaching behaviors, help researchers and teachers analyze classroom teaching behavior, and promote professional development of teachers.

2.2 Kinect System Principle

In 2010 and 2014, Microsoft released KinectV1 and V2 successively. KinectV2 includes a color camera, depth camera, infrared light emitter and microphone, which can realize real-time dynamic capture, image recognition, microphone input, voice recognition, social interaction and other functions. . The official system of Kinect, Kinect for Windows SDK, contains drivers, original sensing data flow development interface, user interface, installation file data, and can be used for secondary development. KinectV2 uses TOF technology (Time of Flight) to obtain depth

image information by calculating the projected infrared rays and the return time after reflection, and then segment the human body from the background image through the machine learning algorithm, and then estimate the three-dimensional coordinate information of the human body joint points (Roque et al. ,2019). It is less affected by the environment and light. It gets rid of the high requirements of traditional motion capture technology in experimental environment, experimental equipment, and the accuracy of markings. It can capture user actions, facial expressions and voice sequences in real time for the purpose of machine interaction. Skeleton tracking technology is the core function of Kinect. This technology uses deep vision technology and uses complex algorithms such as machine learning and matrix changes to determine the three-dimensional coordinates of joint points.

Skeleton tracking technology is the core function of Kinect. The deep vision technology adopted by this technology uses complex algorithms such as machine learning and matrix changes to determine the three-dimensional coordinates of the joint points. The working process includes(He & Li 2020):

①Human contour segmentation: Kinect obtains the depth image information through the depth sensor, and through edge detection, Noise threshold processing and other technologies separate the human target ("T"-shaped object, which will be recognized as a human body by Kinect) from the environmental background to obtain a depth image of the human body;

②Human body part recognition: the human body separated from the depth image Different parts of the human body are identified in the contour, and a large amount of data is used to train and classify through the classification algorithm of the decision forest. Each pixel is labeled with a category label and classification probability to classify various parts of the human body, such as the head and shoulders;

③Joint point positioning: After completing the recognition of human body parts, Kinect analyzes all aspects of the human body and uses machine learning algorithms for joint positioning.

In traditional sports teaching and training, the teaching method is one-to-many, and students' understanding and learning progress are uneven, resulting in poor teaching or training effects. In order to solve these problems, more and more professional sports training began to apply motion capture to sports training and teaching. Kinect determines the accuracy of the exerciser's movements by accurately grasping the contour and position of the exerciser's body, and performs corresponding training or operation according to the movement function. The trainer's technical movements are identified through the Kinect device. After the computer processes the collected data, it makes correct judgments on the technical movements and feeds them back to the practitioners to encourage them to practice repeatedly, correct wrong movements and improve teaching or training efficiency.

The system analysis results show that there are 22 researches on the development and application of Kinect in auxiliary physical education and training; these researches involve competitive events (badminton, basketball, etc.), flexibility events (yoga, Tai Chi, etc.). Kinect's process characteristics as an auxiliary teaching and training tool are:

① Use Kinect-based system equipment to capture human bones and depth information;

② Using self-occluded joint point information restoration algorithms and filters to collect depth images or motion information of each joint Process;

③ Compare and analyze the collected information with the pre-set standard actions;

④ Provide real-time feedback or evaluation to inform the trainer how to adjust the actions and posture, improve the actions in time, and continue training.

3 Model building

With the development of computer science and precision manufacturing, the automation of video-based classroom teaching observation has become an inevitable trend. Multi-modal recognition technology uses a variety of sensory recognition techniques such as depth image and phonetic intonation to perform behavior recognition. This will help to further improve classroom information collection efficiency, coding efficiency, information classification accuracy, and greatly enhance teachers' interpretation of classroom teaching effects. Therefore, in order to realize this idea, this study collected classroom teaching behavior data through the various information technologies, such as depth image analysis technology, human skeleton tracking technology, speech analysis technology and so on.

S-T analysis method is an analytical method that expresses the character of teaching in a graphical way. This analysis method divides the behaviors into two categories: student (S) behavior and teacher (T) behavior, which reduces the ambiguity of behavior classification in the teaching process and increases the objectivity. For the recorded behavior sequence data, it can calculate the T behavior occupancy rate (Rt), the behavior conversion rate (Ch), and plot the Rt-Ch diagram (Jun & Ou, 2011). According to this, the teaching mode adopted in the class can be judged, and the teaching method can be improved by using a visual method. It does not require other complicated calculations, and it is very convenient to use, which is conducive to promotion and implementation.

The depth image analysis technology is used to recognize the objects in the visual filed and analysis the geometric characteristics of objects (Yeloglu et al. , 2015). This technology improves the accuracy of computer image recognition and promotes its development. The human skeleton tracking technology is to recognize the joints of human skeleton and collect the coordinate data of human skeleton. Some scholars use the human skeleton tracking technology in the rehabilitation measurement of disabled people, determine and improve the accuracy of the system's joint tracking, which achieves good results (Mobini et al. , 2014). Some scholars use the human skeleton tracking technology to apply the somatosensory interaction system to multimedia teaching in the classroom environment (Sommool et al. , 2013). The speech analysis technology is to recognize the speech features of human, which has been used in many human-computer interaction systems.

Based on the above analysis, this study constructs a classroom teaching behavior analysis model based on S-T analysis method and multi-modal recognition technology, as shown in Figure 1.

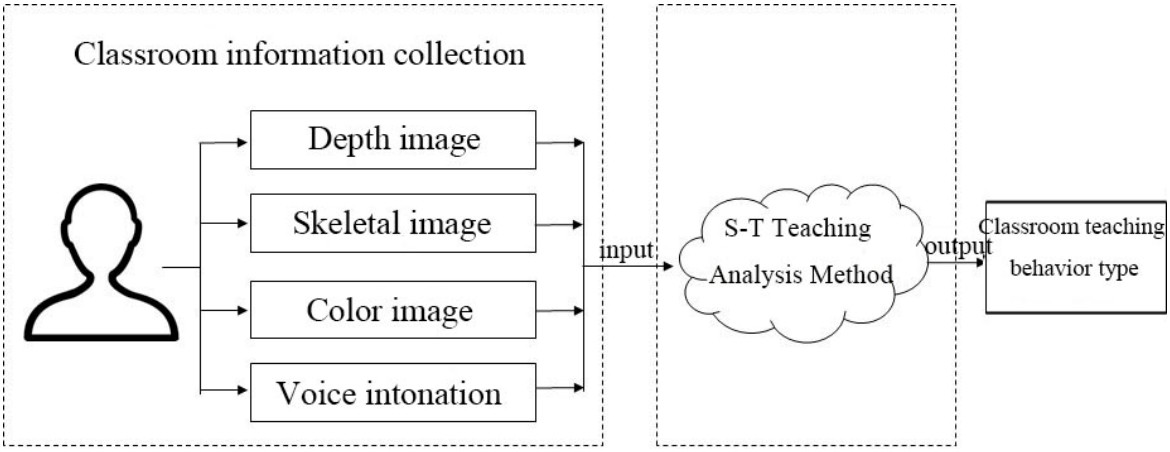

Figure 1 Classroom behavior analysis model

Through the depth image recognition technology and the human skeleton tracking technology, combined with the speech recognition technology, it can collect all the data such as posture and facial behavior of teachers. At the same time, the model combines with the S-T analysis method to encode the teacher behavior data, so as to comprehensively collect the teachers' status, to establish a low-cost, real-time classroom state detection system that does not affect the original listening state of the classroom.

The system software architecture based on S-T analysis method is mainly divided into display layer, business layer and data layer. The display layer is mainly used for the display of the interface and the interaction with the user, mainly using the Microsoft .NET Framework form application technology. On the interface, users can choose to run programs, draw charts, view statistics and view data sources. It is a simple and effective operating system for users. The business layer mainly implements the functions of data processing and chart drawing. It mainly uses the .NET Framework form application and Windows.Forms.DataVisualization. Charting to realize the chart drawing. It is a layer of internal logic implemented throughout the software. The data layer implements the function of storing data and reading data by the user, and uses a text file to store data, as shown in Figure 2. The design idea of the whole system is to complete the coding information of the program design by comparing the continuous changes between every 50 frames.

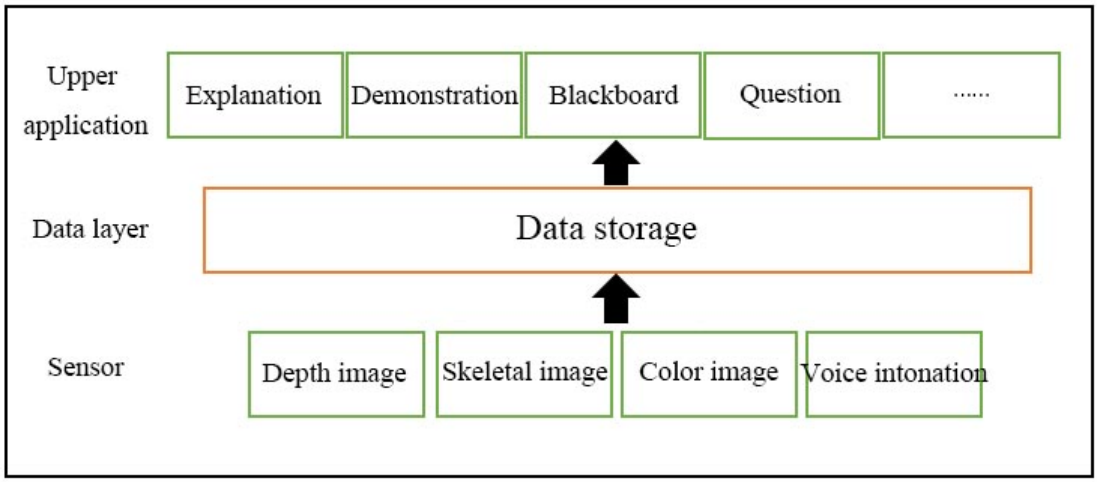

Figure 2 System software architecture diagram

4 Method

4.1 Participants

In this study, two teachers from a university in East China are used as experimental subjects to carry out experiments, and the course of "Human-Computer Interaction" in Educational Information Technology is selected as the research sample. The specific unit course selected is a practical course of human-computer interaction. The content of the course mainly guides students to use six degrees of freedom robotic arms. The course of this unit is relatively difficult, and students need to be guided to complete the course study, program writing, and exchange summary independently.

4.2 Experiment Procedure

The experiment is carried out on the basis of ensuring that the normal classroom order of teachers and students will not be affected. Before the course starts, first of all, arrange the equipment to ensure that the depth sensor camera and high-definition camera can record all the actions of the teacher in the classroom. Monitor whether the equipment is operating normally during the course. Then distribute the course videos to three researchers, and manually code the teacher behavior. Finally, the manual coding result is compared with the system coding. The specific classroom content is required to be designed to be diversified, including at least one of the codes in the S-T teaching analysis method, and to ensure a certain proportion of classroom interaction design.

5 Results

The system encodes and analyzes classroom behavior in a frequency of 5 seconds. In order to detect the reliability of the system, after the automatic coding is completed by the intelligent teaching behavior analysis system, the experiment initiator organizes the experimenter to complete the video-based classroom coding analysis, and finally compares their analysis results. The results show that the coincidence degree between the intelligent analysis system and the manual coding method reaches 86%, which verifies the feasibility and effectiveness of the presented intelligent system.

In order to increase the user's intuitive perception of the time dimension of classroom teaching behavior, this study visualized one course's classroom data according to time while ensuring accuracy. The broken line in Figure 3 not only reflects the changes in teachers' classroom behavior. The abscissa is time in seconds. 1-6 respectively indicate different classroom teaching behaviors, namely explanation, demonstration, blackboard, using various media to prompt, question and name, evaluation and feedback. From the overall behavior data, the teacher's classroom behavior corresponding to the data in Figure 3 has the largest proportion of explanations, indicating that the teacher has more explanation time in the classroom.

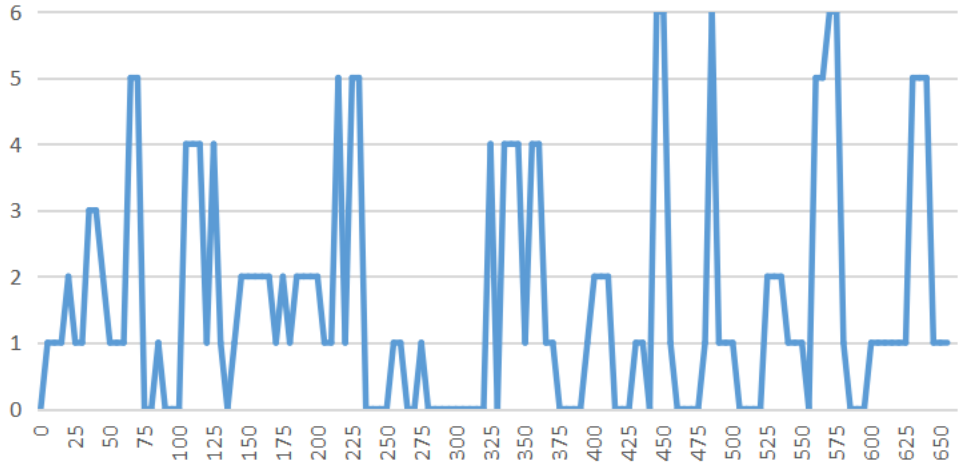

Figure 3 Distributions of classroom teaching behavior

6 Conclusion and Discussion

Researchers and teachers use the proposed intelligent classroom teaching behavior analysis system based on S-T method and multi-modal recognition technology to analyze teaching activities in the classroom, which will improve the quality of classroom teaching and learning effectively, be helpful to the professional development of teachers, and students can also benefit a great deal. This study explored the classroom teaching behavior model, designed and developed the intelligent analysis system to reduce the difficulty of classroom teaching behavior observation, improve the efficiency and quality of classroom teaching activities. It is of great significance to improve the quality of education.

This research has achieved multi-modal classroom behavior recognition, but the research currently only uses two teachers as samples for experiments. When it is extended to more teachers, different behaviors of different teachers need to be considered to improve the accuracy of classroom behavior recognition degree. Future research will add students' classroom behaviors to form a complete multi-modal classroom behavior recognition system for teachers and students.

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Teachers' Experiences with Emergency Remote Teaching During the COVID-19 Pandemic

Jennifer Lipton,
Wilkes University

Jin Mao,
Wilkes University
Corresponding Author (jennifer.lipton@wilkes.edu)

The COVID-19 pandemic quickly and drastically changed the field of education in 2020. Teachers faced challenges when confined to their homes and had to begin emergency remote teaching with their students. It is important to recognize what these teachers experienced and find ways to prepare for a crisis-prompted teaching situation in the future. The purpose of this phenomenological study was to explore the lived experiences of Pennsylvania elementary classroom teachers who engaged in emergency remote teaching during the COVID-19 pandemic. Semi-structured Zoom interviews of eight elementary teachers who participated in emergency remote teaching provided data for qualitative phenomenological analysis. Findings revealed five themes: Emotional stress with the transition to emergency remote teaching, technological and instructional barriers, changes in content, pedagogy and technology use, increased workload and self-reliance, and positive relationships with students and colleagues. Mishra and Koehler's (2006) technological, pedagogical, and content knowledge (TPACK) framework was used to guide the data collection and discussion of the findings in this study. The practical implications of this study include training and policies related to pandemic or emergency teaching planning.

Keywords: COVID-19, Emergency Remote Teaching, Teachers

INTRODUCTION

In December 2019, a novel coronavirus was identified in a virus outbreak in Wuhan, China (Centers for Disease Control and Prevention [CDC], 2020a; CDC, 2020b). Schools across the nation closed in order to prevent the spread of this novel coronavirus. As early as late February 2020, superintendents and governors closed schools across the United States, first temporarily and then extending to the rest of the academic year, affecting at least 50.8 million public school students (Decker et al., 2020). On March 13, 2020, Pennsylvania Governor Tom Wolf ordered the closure of all schools in Pennsylvania for two weeks, a measure aimed at slowing the spread of the COVID-19 ("Governor Tom Wolf," 2020). School teachers in Pennsylvania had to find an alternate means of providing education to their students, turning to emergency remote instruction for the remainder of the spring of 2020. Many teachers found themselves unprepared for the challenges they faced (Hodges et al., 2020).

About COVID-19

Coronaviruses are a large family of viruses that may cause illness in animals or humans (WHO, 2020). In humans, coronaviruses cause respiratory diseases as simple as the common cold or as complex as severe diseases such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS) (Centers for Disease Control and Prevention [CDC], 2020a; WHO, 2020). COVID-19 can be spread from person to person via small droplets in the nose or mouth when a person coughs or exhales (CDC, 2020a; WHO, 2020). On February 11, 2020, the World Health Organization (WHO) announced the new coronavirus's official name, using their best practice to name new human infectious diseases (CDC, 2020a). The CO stands for corona, the VI for the virus, the D for disease, and -19 for the year when the outbreak began, 2019 (CDC, 2020a). On March 11, 2020, the WHO declared the novel coronavirus outbreak a global pandemic (Cucinotta & Vanelli, 2020). The potential for spread led to social distancing and mask use across the country.

COVID-19 and Emergency Remote Teaching

Remote teaching, which is different from online teaching, allows educators to teach with technology to ensure students' continuity of learning at a distance (Trust & Whalen, 2020). Remote teaching occurs "during emergencies when teachers and students are not accustomed to using online platforms or technology to deliver instruction" (Russell, 2020). Since March 2020, emergency remote teaching has become the terminology used to refer to this teaching type during the pandemic (Craig, 2020; Hodges et al., 2020).

As a result of emergency remote teaching, teachers experienced an unprecedented and unplanned disruption to education that changed the work of many teachers suddenly and in many aspects (Kaden, 2020). Teachers around the world "frantically and emergently switched to remote teaching" (Schlesselman, 2020). Teachers were given anywhere from a few hours to a few weeks to prepare to move all instruction to a remote format (Gacs et al., 2020) and expected to become online teachers overnight (Gudmundsdottir & Hathaway, 2020). Teachers were suddenly confined to working from home, removed from students, and challenged to learn new technologies (Kaden, 2020).

When teachers begin instructing in an online environment, they generally have time to meet their needs before beginning (Gacs et al., 2020; Moore-Adams et al., 2016). Many teachers who experienced emergency remote teaching did not have time to prepare or receive the professional development necessary to begin such a massive undertaking (Paesani, 2020). With this sudden transition to emergency remote teaching, educators faced an abnormal environment where they had to get ready quickly, without the help commonly available and access to quality resources, all while confined to their homes (Huang et al., 2020; Wake et al., 2020). Teachers had to use whatever resources they had access to at the time without any clearly defined standards or understanding of online teaching (Schlesselmen, 2020). This move to emergency remote teaching resulted in an increased workload for teachers, challenging them to provide meaningful educational experiences to their students, despite what was happening around them (Kaden, 2020).

The change to emergency remote teaching happened so fast that it is essential to pause and reflect on those experiences (Pacheco, 2020). The emergency remote teaching situation experienced by educators in the spring of 2020 offered many "lessons on preparedness that can

and should be addressed in anticipation of another crisis teaching situation" (Pacheco, 2020). The COVID-19 pandemic completely disrupted the education system and forced a wake-up call to strengthen public education (Kaden, 2020). Teachers need to be prepared to teach entirely online and immediately shift to emergency remote teaching (Major, 2020). Teachers will need tools and guidance should the need for emergency remote teaching arise in the future (Gacs et al., 2020).

METHODOLOGY

This study employed a qualitative design using a phenomenological approach.

Participants

Interview data were collected from eight teachers at various public schools in Pennsylvania. The participants were recruited from different schools and elementary grade levels (kindergarten through sixth) to get stories from multiple contexts, richer data, and avoid homogenizing their experiences. A purposeful sampling strategy was used and the criteria for selection of the participants included: (i) being elementary classroom teachers in Pennsylvania who transitioned to emergency remote instruction due to the COVID-19 pandemic, (ii) having no prior experience with online teaching or emergency remote teaching, (iii) being self-contained elementary classroom teachers. Eight participants were purposefully selected to participate in the study using these criteria.

Instrumentation

The interview protocol consisted of 14 semi-structured questions. The interview protocol was created based on Brinkmann and Kvale's (2015) method of preparing for the interview by setting the stage and working off a script, yet moving through the interview like a conversation between "two partners about a theme of mutual interest" (p. 149). The interview protocol was designed using topics and questions related to the focus of the study. The interview protocol contained questions aimed at gathering a detailed description of the participants' experiences with the phenomenon. This approach is supported by Merriam and Tisdell's (2016) findings that interviewing is the primary method of data collection to arrive at the essence of a lived phenomenon. The questions asked in the interview protocol were based on the work of Brinkmann and Kvale (2015), who emphasize the importance of attempting to understand the world from the participants' point of view.

Data Collection and Analysis

Interviews were conducted via Zoom due to ongoing safety concerns related to social distancing and the COVID-19 pandemic. The Zoom interviews were recorded using the application; the Zoom application allows users to record audio and save it right to the computer in an M4A format. M4A is an extension that signifies an audio recording. Each interview lasted between 30 and 50 minutes. They were transcribed using the website Otter, a service that turns voice conversations into transcribed notes. The transcripts were reread for precision twice and then sent individually to each participant to check them for accuracy and report any discrepancies. Having the participants review the transcripts was done to increase the reliability

and validity of the data. The transcripts were then coded using Dedoose. The data were analyzed based on code frequency, key terms, and themes across all interviews. Pseudonyms were used for confidentiality.

RESULTS

The analysis of the interviews revealed five themes resulting from the categorization of codes: emotional stress with the transition to emergency remote teaching, technological and instructional barriers with emergency remote teaching, changes in content, pedagogy and technology due to emergency remote teaching, increased workload and self-reliance with emergency remote teaching, and positive relationships during emergency remote teaching.

Emotional Stress

The study revealed that no one expected a worldwide pandemic and did not predict the resulting shift in education. Teachers had difficulty grasping the notion of what was happening in the world. They experienced stress when setting up their new virtual classrooms and working from home.

Fay: I cried. Like cried. I cried because, you know... And then, I don't know if we had a week to prepare or try to figure it all out. But no, I think I just went through a realm of emotions, you know. First of all, we're scared. We don't know what's going on.

Anne: Like just teacher burnout, we worked all day and then all night. We were always willing to do it, but it led to extremely long, long, long days. I have children I need to take care of, so it was hard balancing my family and being a teacher and supporting all of their families at the same time.

Technological and Instructional Barriers

This study revealed that all teachers experienced difficulty with device access and connectivity. The teachers in this study were without their materials and had issues with students attending online classes and completing their work.

Anne: We are a country school. Some of our children's homes don't have cable TV running to their properties. So, to get a hotspot to work in a wooded area or where a mountain is blocking you, sometimes they were very spotty. So, we had a lot of messages that they were behind because it was difficult for them to complete the assignments with the lagging.

Jane: It's obviously not where I wanted it to be. Because it wasn't direct, I wasn't in person with my students. I did the best I could with what I had to work with. Knowing I didn't have access to any of my materials at school, so I was able to just take my thoughts and put them into writing and pass that along to the parents and hope that, you know, they had things at home that they

could utilize to practice those skills. After they left on March 13th, I had no interaction or contact with my students at all.

Changes in Content, Pedagogy, and Technology

The teachers in this study all experienced changes and adaptations to content in some way. The teachers either changed the content they were used to teaching or taught the same content but with a different effort. The teachers all reported learning how to use new technology and then altering their content and practices to work with the new technology use.

Anne: A colleague of mine mentioned Loom, so I started recording myself teaching the lessons. The students would have direct links to me teaching them on a recording. 90% of it was asynchronous. I would hold a Zoom every day. They had to sit and listen from their dining room tables instead of the classroom.

Lila: I saw a lot of creativity come out of kids that I don't know if I would have seen had we not gone remote. I really did see some kids do some projects that I felt like, wow, they put forth a lot of time and effort into this. I got to see a different side of the kids in that manner.

Increased Workload and Self Reliance

All participants found themselves with a new, more intense workload in addition to needing to rely on their ability to provide instruction to students remotely since the time and resources for professional development were not perfect for this situation.

Sue: They kept on throwing things at us. Like, you have to do this. You have to document that. And there was not much guidance; it was just a list of to-dos without how to do them. And it worked out wonderfully, but there were really high demands on us. I truly felt like I was flying the plane as I was building it. Each day I would learn something new, or something would go wrong. And I would have to learn on the fly how to fix it. I did not have my materials. I was learning not only how to do Zoom and teach material online, but I was home as well.

Nancy: On a Monday and a Friday, I had two different meetings because of working schedules and stuff like that. During the day, we were required to be there for almost like office hours. We needed to respond to a parent. I spent a lot of time creating different content for the kiddos.

Positive Relationships

Each of the eight participants noted positive relationships with either colleagues, students, or both. Some even found positive relationships with administration or students' parents during the pandemic. The participants found that the circumstances allowed them to get to know their students on a level that may not have been possible without the pandemic. The reliance on their coworkers to get through this unprecedented time also strengthened their relationships with each other.

Fay: The students really just wanted to talk to us. And I think we were told that's pretty much okay. Especially for eight-year-olds, you know, it was just to check in. They most wanted us like making sure the kids were okay. Not like their safety but you know like, mentally okay. I would do one on one meetings with them. And that didn't really work. Because, again, they just want to show you, their cat. And I'm like, okay, let's talk about your math.

Pam: We have like a very close group with our special ed teachers. So, we're constantly in group chats together; we opened like Google Classrooms to communicate, share ideas, like if we wanted to use the same thing in our classroom. So just the ongoing communication and collaboration, we always share ideas with each other, which is helpful.

DISCUSSION AND CONCLUSION

Discussion

This study's findings provided an understanding of the lived experiences of elementary teachers who participated in emergency remote teaching during the COVID-19 pandemic. The analysis of the interviews uncovered five themes related to these experiences.
Each participant described the changes they experienced in their teaching as a result of emergency remote teaching.

All participants noted emotional stress with the transition to emergency remote teaching; they felt fear, frustration, and uncertainty. The teachers were not prepared to become emergency remote teachers. Even the teachers with advanced technological skills reported they never expected a worldwide pandemic to change how they provided education to their students. Teachers were given little to no notice that everyone would be sent home to learn, at first for two weeks and then for the remainder of the 2019-2020 school year. The teachers did not have time to prepare and gather all the materials they would need to instruct from home and found this time very stressful. Teachers reported they did not get clear directions from their administrators, who were also trying to figure out what was going on and what to do.

Each of the participants noted numerous issues with technological and instructional barriers when conducting emergency remote teaching. Teachers faced technological barriers right away because not all students had a device at home. Many districts worked to get devices to students, but this took time. Some teachers were surprised, but students lacked access at home, so districts had to provide things like hot spots to connect to the Internet. The schools in rural areas had consistent connectivity problems, with students reporting glitchy connections or lack of connection in bad weather. The teachers had to figure out how to use these platforms and apps and then teach the students, who were also unfamiliar. As emergency remote teaching continued, teachers encountered consistent technology problems and solved them as they came up.

They also faced changes that had to be made to their content, pedagogy, and use of technology with their students. They had to learn to use technology as the main part of their teaching instead of an add-on. They had to learn how to make technology work with their existing content and pedagogy. They had to change some content and pedagogy to adapt to using technology with their students. The teachers had to learn how to use Zoom or Google Meet to communicate with their students and adjust to not being face-to-face. They had to record themselves teaching. Many teachers who never used platforms like Google Classroom reported that they still use it because they now like it. Teachers used the Internet and different websites to

find activities and content instead of their teacher manuals and traditional curriculum. The teachers in this study noted they had to change how they were teaching because they could not hold small groups, do science experiments, or use other hands-on methods to teach.

Most participants noted a substantial increase in workload and the need for self-reliance when developing ways to reach students during the school shutdowns in the spring of 2020. The teachers in this study reported not having many directions from their administrators because they were unsure of what to do. While many teachers received some guidance, the participants had to figure out what to do independently. The participants had to take on many new tasks such as contacting the parents and students, setting up their virtual classrooms, and learning the new platforms and apps. These tasks were not only unfamiliar but also time-consuming. Teachers spent many hours reaching out to parents, trying to find devices and connectivity for students. The teachers had to figure out how to use things like Zoom and Google Classroom. They had to spend the time to look for resources, websites, and materials that could be used online with their students. Many teachers delivered devices or materials themselves directly to the students' homes. Many of the teachers in this study said they felt like they were on their own. Some said they had things being thrown at them without being told exactly how to do it.

All participants expressed having experienced positive relationships with either colleagues or students during emergency remote teaching. The teachers in this study stated that the students looked forward to the Zooms or online meetings, even when the discussion was not academic. They felt it gave the students something to look forward to and created a sense of normalcy at a very uncertain time. It was not always academic, and sometimes the students and teachers would talk about what was going on in the world or show their pets. Some of the participants thought this made the students feel safe, and they enjoyed being able to check on the students, both physically and mentally. Many teachers felt that emergency remote teaching allowed them to get to know their students better, bond with them, and see certain qualities they may not have seen in a traditional format. All eight participants in this study noted positive relationships with their coworkers due to emergency remote teaching. The teachers worked together, sharing materials and ideas. They were texting and calling each other constantly. They found ways to get through this difficult time together, and they split up tasks to share the workload. Some teachers felt that emergency remote teaching brought them closer to their colleagues because they depended on each other.

Implications for Future Practice

School districts in the post-COVID-19 world must be ready for the possibility of a crisis-prompted teaching situation in the future. Changes can be made to education to prepare administrators, teachers, parents, and students to face something like a worldwide pandemic. The emergency remote teaching situation experienced by educators in the spring of 2020 offered many "lessons on preparedness that can and should be addressed in anticipation of another crisis teaching situation" (Pacheco, 2020). The research done in this study suggests school districts need to look at the measures they have in place for teaching during an emergency, such as a pandemic.

First, the results of this study demonstrate the need for school districts to have a 1:1 device program in place, where each student has a mobile device that they use in school and at home. Based on this study's findings, educators felt unprepared to enter emergency remote teaching because their students did not have the devices necessary to connect with the teachers.

Second, school districts might also want to examine the professional development offered for technology use in the classroom and align it with teachers' needs and daily use. School districts should consider ongoing professional development in the practical use of technology. The professional development has to be relevant and applicable to their classrooms. Third, teachers might want to increase their daily technology integration in their classrooms. A suggestion would be to get students and teachers familiar with the devices and use those devices in conjunction with a specific platform, such as Google Classroom, to communicate with students from a distance. Fourth, school districts should have a pandemic plan in place. A clear plan will help teachers face an emergency remote teaching situation with more confidence and less of a sudden increase in workload. The support and guidance on what is expected will save teachers time and make them feel less unprepared for an emergency.

Recommendations for Future Studies

There is value in studying teachers' experiences with emergency remote teaching to evaluate what did and did not work and what we can learn to improve current and future practice (Hartshorne et al., 2020). The COVID-19 pandemic completely disrupted the education system and forced a wake-up call to strengthen public education (Kaden, 2020). This study was conducted to elementary classroom teachers' experiences with emergency remote teaching during the COVID-19 pandemic. The data analyzed from this study suggests the need for further research on the phenomenon of emergency remote teaching.

All school districts in the United States could benefit from additional research about teaching during the COVID-19 pandemic. It is recommended that this research study be replicated with teachers from various grade levels and subject areas. Future studies on emergency remote teaching should include teachers from middle school and high school. Studying middle school and high school teachers' experiences and comparing them to that of an elementary school teacher would provide a basis for comparison to determine whether the themes for emergency remote teaching are seen at all grade levels. This comparative study would also highlight the potential differentiated needs of teachers transitioning to emergency remote teaching.

A future study on emergency remote teaching could include the experiences of individuals other than the teachers. Studies could be done with administrators, parents, or students. The unique perspective of these groups of people could be compared and contrasted to teachers. The input from administrators, parents, and teachers could provide valuable information for educators regarding the best methods of conducting emergency remote teaching.

Another recommendation for future studies is to conduct an identical study and include teachers from other states. Because every participant in this study had experience as a Pennsylvania teacher, it would be interesting to contrast the teachers' experiences in other states. States experienced shutdowns due to COVID-19 at different rates and with different guidelines for emergency remote teaching.

An additional recommendation for a future study is a study on existing pandemic plans. There is a need for future research studies to determine if school districts have adopted a pandemic plan or updated one previously in place. The details of these pandemic plans could provide valuable insight to school districts that lack one. School districts can use a study like this to provide support and specific guidance outlining what should be done for emergency remote teaching in their pandemic plan.

A study could be conducted comparing the experiences of male to female teachers. Since all of the participants in this study happened to be female, the experiences of male elementary teachers were not represented.

Finally, a research study could compare schools with 1:1 device programs and educational platforms in place to schools that were not using technology daily with their students before the pandemic. The study could analyze the difficulty of the transition for these two groups.

Conclusion

The COVID-19 pandemic found educators across the world in a situation they never expected. The demands placed on teachers to suddenly switch to emergency remote teaching revealed that many school districts were unprepared to teach virtually due to a pandemic. This study aimed to examine the experiences of elementary classroom teachers who participated in emergency remote teaching. This study was necessary because it is important to step back and look at what teachers experienced during a worldwide pandemic and learn from those experiences. There was a dearth of research on online learning but minimal research on emergency remote teaching due to its timely nature. This study's findings indicate that the experiences of elementary classroom teachers with emergency remote teaching were complex and characterized by emotional stress with the transition, technological and instructional barriers, changes in content, pedagogy, and technology, increased workload, and positive relationships. Future studies on emergency remote teaching should help to further the conversation about how to be best prepared for a crisis-prompted teaching situation in the future.

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Investigation of Psychological and Environmental Factors that Influence Assignments Completion

Rie MATSUOKA
1721528 @ ed.tus.ac.jp
Master Student
Department of Mathematics and Science Education, Graduate School of Science,
Tokyo University of Science
1-3 Kagurazaka, Shinjuku-ku, Tokyo, 162-8601, Japan

Yuki WATANABE
wat @ rs.tus.ac.jp
Professor
Department of Mathematics and Science Education, Graduate School of Science,
Tokyo University of Science
1-3 Kagurazaka, Shinjuku-ku, Tokyo, 162-8601, Japan

1. Introduction

1.1 Education in Today's Japan

The Ministry of Education, Culture, Sports, Science, and Technology (MEXT) (2020) has indicated the need to improve classes from the perspective of proactive, interactive, and authentic learning (so-called active learning) in the new curriculum guidelines to be implemented in high schools on an annual basis starting in 2022. It is essential to realize this improvement, not within a single lesson but a coherent unit or subject matter. In addition, since there will be no reduction in learning content from the existing curriculum guidelines, high school mathematics departments are required to plan lessons that consider teaching content and time allocation (MEXT, 2018). Thus, in today's Japan, students are expected to study more in-depth content in a limited amount of time.

Therefore, flipped classroom teaching is an effective way to realize the improvement of teaching required today.

1.2 Flipped Classroom

According to Bergmann and Sams (2012), a flipped classroom is a learning method in which students do essential learning, such as the content of explanatory lectures, before class as homework, and learning necessary for retention of knowledge and cultivation of applied skills, such as tutorials and project learning. Abeysekera and Dawson (2015) found three critical components of flipped classroom teaching:

1. Information-transmission teaching moves to outside of class time
2. Lesson time used for learning activities
3. Students require completing pre-and/or post-class activities to benefit from in-class activities fully

These components suggest that it is possible to incorporate active learning into class time without reducing the learning content by introducing flipped classroom teaching.

One of the characteristics of flipped classroom teaching is the relationship between home-studying (preparation and review) and face-to-face teaching. According to Shinogaya (2012), all learning breaks down into three stages: prior learning, core learning, and post-learning. Shibukawa (2021) summarized the flow of learning in lecture-based and flipped classroom teaching based on three stages of learning (Table 1).

Table 1. Difference between lecture-based class and flipped classroom

<table>
<tr><th>Learning Stage</th><th>Lecture-based Teaching</th><th>Flipped Classroom Teaching</th></tr>
<tr><td>Prior Learning</td><td>Preparation
Ex) Reading Textbook</td><td rowspan="2">Pre-Class Learning
Ex) Watching lecture videos
Acquire new knowledge</td></tr>
<tr><td>Core Learning</td><td>Class Lesson
Ex) Knowledge Acquisition</td></tr>
<tr><td rowspan="2">Post Learning</td><td rowspan="2">Revision
Ex) Summarize Class</td><td>Class Lesson
Ex) Engaging in developmental activities</td></tr>
<tr><td>Post-Class Learning</td></tr>
</table>

On the one hand, in lecture-based teaching, students learn the content of the class through preparation, acquire knowledge in the face-to-face class lesson, and practice problems and summarize the class content in the revision. On the other hand, in a flipped classroom teaching, the student acquires knowledge of the lesson's content in the pre-class learning, performs exercises in the face-to-face class lesson, and summarizes the content in the post-class learning. In this way, in the flipped classroom, students need to learn new knowledge on their own while studying at home. Therefore, the materials for the pre-class learning in the flipped classroom need to be designed so that the teacher's explanation of the study contents, the pre-class learning, and the face-to-face class lesson is considered one learning process.

However, the implementation of prior learning can be problematic because there are no instructors present where learners can conduct prior learning.

1.3 Problems with Pre-Class Learning in Flipped Classroom

Some prior studies have shown that pre-class learning did not work well in flipped classroom teaching. One of the reasons is that learners do not carry out pre-class learning. For example, in Yamamoto et al. (2018) 's practice, a teacher needs to provide individual attention if students do not do the pre-class learning. Furthermore, Long et al. (2017) found that students might not prepare for pre-class learning, so teachers need to encourage their motivation for pre-class learning before in-class activities for all students to enjoy active learning. Wei et al. (2020) also stated that teachers need to encourage students to conduct pre-class learning to make in-class activities more active. Thus, the learner's implementation of prior learning is a necessary element for the success of the flipped classroom.

Based on the above, we thought it necessary to examine what kind of support is needed to improve the rate of students' implementation of assignments.

2. Purpose

It is still unclear what kind of support effectively encourages high school students to carry out their assignments. Therefore, this study aims to investigate the difference in the awareness of the students who submitted their assignments and those who did not submit their assignments, examine the factors that affect the students' implementation of the assignments, and propose support methods for each factor.

3. Methods

3.1 Participants of Research

We surveyed 80 second-year high school students (40 students in each of two classes) enrolled in a public high school in Chiba Prefecture, Japan. The participants are taking a course called "Mathematics B," The unit covered in this study is "Space Vector."

3.2 Flow of Research

Figure 1 shows the flow of this survey. This survey was conducted within the "Space Vectors" unit in October 2020. The subject took a class on "Components of vectors and operations with components" within the unit. In the class, new knowledge was explained, and problems were practiced. In the review assignment, the students were required to practice five similar problems to the problems in the class. After the students submitted their assignments, a questionnaire survey was conducted on their motivation to perform the assignments.

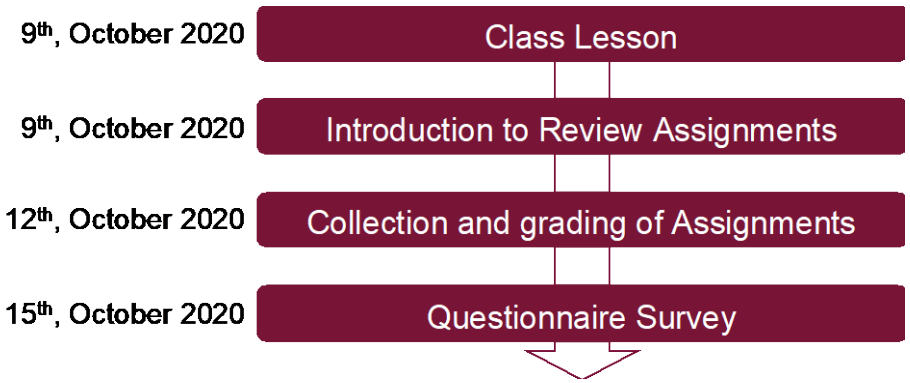

Figure 1. Flow of Research

3.3 Questionnaire survey

A unique questionnaire was developed and administered to investigate the psychological situation and the learning environment in the students were performing the assignment. The questionnaire items were divided into three categories based on the different ways in which the students carried out the assignments:

(1) When they carried out the assignments and finished them
(2) When they carried out the assignments but did not finish them
(3) When they did not carry out the assignments

The total number of questions was 17 items: (1) 7 items, (2) 5 items, and (3) 5 items, and each item used a 5-point Likert scale (1 = disagree, 5 = very much agree). In addition, they were asked about the most significant causes for each of the times when they performed the assignments and when they did not perform the assignments in an open-ended question.

4. Results

Among the 80 participants in this study, 53 (approximately 66%) who responded to the questionnaire without flaws were included in the analysis. Table 2 shows the implementation status of the assignments for the 53 participants in the analysis.

Table 2. Status of students' implementation of the assignments

Group	n	Score (5-point scale)	
		M	*SD*
Submitted	42	4.36	0.84
No-Submitted	11	-	-
total	53		

4.1. Reliability of the Questionnaire

To investigate the reliability of the original questionnaire, Cronbach's alpha was calculated for the responses to the 17-item questionnaire. As a result, ± = 0.73, the results of the questionnaire used in this study are considered reliable and will be analyzed.

4.2. Attitudes toward Assignment Implementation and Environmental Differences

In this research, a comparison of means was conducted on the responses to the questionnaires to examine whether there were differences in attitudes and environments between students who submitted the review assignment (submitted group) and those who did not submit the assignment (not submitted group). Shapiro-Wilk's normality test was conducted on the results of the questionnaire for each group, and no normality was found. In addition, there was a difference in the sample size of each group (submitted group=42, not submitted group=11). Therefore, Mann-Whitney's U test was adopted as the analytical method for comparing the means.

We compared the differences in attitudes toward the implementation of the assignment between the submitted and un-submitted groups based on the responses to the first question (When they carried out the assignments and finished them) of the questionnaire survey. The results are shown in Table 3.

Table 3. Differences in attitudes toward completing assignments

	(1) When they carried out the assignments and finished them	Submitted		Not Submitted		M_1-M_2	*U*	*r*
		M_1	SD_1	M_2	SD_2			
1	I do assignments because I believe that I should do the assignments at	4.26	0.59	3.55	1.04	0.71	136.50†	0.32

school.

2	I do assignments because I believe that turning them in is related to my grades.	4.07	0.78	3.64	1.12	0.43	178.00	0.18
3	I do assignments because it is necessary for me to do so to understand and master the course content.	3.83	0.85	3.45	1.13	0.38	187.00	0.14
4	I do assignments because I know the purpose of doing them.	3.67	0.85	3.09	1.14	0.58	148.50†	0.26
5	I do assignments because I like learning about the subject assigned.	2.76	1.10	2.45	1.04	0.31	195.00	0.11
6	I do assignments because I enjoy learning about the subject assigned.	2.71	1.15	2.45	1.21	0.26	204.00	0.08
7	I do assignments well in advance of the deadline.	2.76	1.19	2.45	1.44	0.31	196.00	0.12

n=53, 5-point Likert scale †p<.100

As a result of comparing students' attitudes toward "carrying out and completing assignments," there was a significant tendency toward the submitted group on the p<.100 criterion for items (1)-1 and (1)-4.

We compared the difference in the awareness of the submitting group and the not-submitting group regarding the case where they carry out the assignments but do not finish it, based on their responses to the second question (When they carried out the assignments but did not finish them) of the questionnaire survey. The results are shown in Table 4.

Table 4. Differences in attitudes when assignments are done but not completed

(2) When they carried out the assignments but did not finish them		Submitted		Not Submitted		M_1-M_2	U	r
		M_1	SD_1	M_2	SD_2			
1	I do not finish assignments when I feel that they are too much.	3.14	1.18	2.73	1.42	0.41	184.50	0.14
2	I do not finish assignments when I feel that I cannot solve the problems.	2.50	1.09	3.27	1.35	-0.77	153.00†	0.24
3	I do not finish assignments when I do not know what to refer to when doing my assignments.	3.02	0.84	3.45	1.37	-0.43	162.00	0.22
4	I do not finish assignments when I do not have enough time due to assignments in other subjects.	2.83	1.06	2.73	1.01	0.10	221.00	0.03
5	I do not finish assignments when I	3.05	1.31	3.00	1.34	0.05	225.00	0.02

	don't have time for club activities, lessons, cram school, or other commitments.							

n=53, 5-point Likert scale $^{\dagger}p<.100$

As a result of comparing the students' attitudes toward "doing the assignment but not finishing it," there was a significant tendency toward the not-submitted group on the $p<.100$ criterion for item (2)-2.

We compared the differences in attitudes of the submitted group and the un-submitted group regarding the non-implementation of assignments based on their responses to the third question (When they did not carry out the assignments) of the questionnaire survey. The results are shown in Table 5.

Table 5. Differences in attitudes when assignments are not completed

(3) When they did not carry out the assignments		Submitted		Not Submitted		M_1-M_2	U	r
		M_1	SD_1	M_2	SD_2			
1	I do not do assignments when I forget that I have them.	2.90	1.28	2.73	1.10	0.17	217.00	0.04
2	I do not do assignments when they do not count toward my grade.	3.48	0.97	3.00	0.89	0.48	165.50	0.21
3	I do not do assignments when I feel that they are not necessary for my learning.	3.64	1.03	3.00	0.77	0.64	143.00*	0.28
4	I do not do assignments when I feel that doing them is a hassle.	3.83	0.88	3.18	0.98	0.65	150.50†	0.26
5	I do not do assignments when I do not understand the purpose, meaning, or intent of doing them.	3.71	0.94	3.36	0.92	0.35	182.50	0.15

n=53, 5-point Likert scale $^{*}p<.050$, $^{\dagger}p<.100$

As a result of comparing the students' attitudes toward not carrying out assignments, there was a significant difference in the submitted group based on $p<.050$ in item (3)-3. Furthermore, in item (3)-4, there was a significant trend toward the submission group at the $p<.100$ criterion.

4.3. Categorization of Learner Characteristics of Assignment Implementation

There was no significant difference between the submitted group and the un-submitted group when the difference in the attitude toward the assignments was examined by comparing the mean values. Therefore, we conducted a factor analysis to examine the factors that influence students' performance of the assignments. The questionnaire items were categorized into two types: items related to factors for performing the assignments and items related to factors for not

performing the assignments, and factor analysis was conducted on each of the two types of items to identify factors that influence the performance of the assignments.

First, to examine the students' motivation to perform the assignments, factor extraction using the principal factor method and exploratory factor analysis using ProMax rotation were conducted on (1) of the questionnaire. The results are shown in Table 6.

Table 6. Students' attitudes toward performing the assignment

Questionnaire		factor		
		Ⅰ	Ⅱ	Ⅲ
(1)-5	I do assignments because I like learning about the subject assigned.	0.94	0.02	0.01
(1)-6	I do assignments because I enjoy learning about the subject assigned.	0.94	-0.03	0.03
(1)-4	I do assignments because I know the purpose of doing them.	0.16	0.8	-0.02
(1)-3	I do assignments because it is necessary for me to do so to understand and master the course content.	-0.14	0.62	-0.04
(1)-7	I do assignments well in advance of the deadline.	0.05	0.54	-0.18
(1)-1	I do assignments because I believe that I should do the assignments at school.	-0.11	0.54	0.32
(1)-2	I do assignments because I believe that turning them in is related to my grades.	0.05	-0.11	0.8
Cronbach's alpha		0.94	0.69	-
factor correlation	Ⅰ			
	Ⅱ	0.16		
	Ⅲ	0.03	0.31	

n=53, Kaiser-Mayer-Olkin's measure: .57, Bartlett's test: $Ç^2$=129.13.
Factor extraction by principal factor method, ProMax rotation

The results of the factor analysis showed that the motivation to perform the assignments was categorized into three factors. The factor I consisted of (1)-5 and (1)-6, Factor II consisted of (1)-4, (1)-3, (1)-1, and (1)-7, and Factor III consisted of (1)-2. There was also a weak inter-factor correlation between factors II and III.

Next, to examine students' motivation to not perform the assignments, factor extraction using the principal factor method and exploratory factor analysis using ProMax rotation were conducted on (2) and (3) of the questionnaire. Also, all items were reversed because the questionnaire items were written in such a way as to ask for negative items. The results are shown in Table 7.

Table 7. Students' attitudes toward not performing the assignment

Questionnaire		factor			
		Ⅰ	Ⅱ	Ⅲ	Ⅳ
(3)-5	I do not do assignments when I do not understand the purpose, meaning, or intent of	0.86	0.13	-0.06	-0.10

doing them. (R)

(3)-3	I do not do assignments when I feel that they are not necessary for my learning. (R)	0.73	0.08	0.06	-0.06
(3)-4	I do not do assignments when I feel that doing them is a hassle. (R)	0.50	-0.23	0.03	0.30
(2)-5	I do not finish assignments when I don't have time for club activities, lessons, cram school, or other commitments. (R)	-0.04	1.01	-0.05	0.00
(2)-4	I do not finish assignments when I do not have enough time due to assignments in other subjects. (R)	0.13	0.49	-0.01	-0.01
(2)-2	I do not finish assignments when I feel that I cannot solve the problems. (R)	-0.15	0.05	0.85	0.00
(2)-3	I do not finish assignments when I do not know what to refer to when doing my assignments. (R)	0.15	-0.11	0.67	-0.17
(3)-1	I do not do assignments when I forget that I have them. (R)	-0.10	0.00	-0.16	0.62
(3)-2	I do not do assignments when they do not count toward my grade. (R)	0.08	-0.02	-0.06	0.58
(2)-1	I do not finish assignments when I feel that they are too much. (R)	0.09	0.21	0.22	0.48
	Cronbach's alpha	0.73	0.67	0.63	0.59
	factor correlation Ⅰ				
	factor correlation Ⅱ	0.30			
	factor correlation Ⅲ	0.16	0.35		
	factor correlation Ⅳ	0.37	0.41	0.49	

n=53, Kaiser-Mayer-Olkin's measure: .55, Bartlett's test: $Ç^2$=146.47.
Factor extraction by principal factor method, ProMax rotation (R): Reverse items

The results of the factor analysis showed that the motivation to perform the assignments was categorized into four factors. The factor I consisted of (3)-5, (3)-3, and (3)-4, Factor II consisted of (2)-4 and (2)-5, Factor III consisted of (2)-2 and (2)-3, and Factor IV consisted of (2)-1, (3)-1 and (3)-2. Also, weak inter-factor correlations were found between Factor I and Factor II, Factor I and Factor IV, and Factor II and Factor III, while moderate inter-factor correlations were found between Factor II and Factor IV, and Factor III and Factor IV, respectively.

5. Discussion

The above results suggest that the students in the submitted group feel more obligated to submit assignments than the students in the un-submitted group for the subjects of this study. In addition, it is thought that students are aware that they should perform and submit the assignments that are given to them regardless of the effect of performing the assignments on

their academic performance or the ease of performing the assignments. Therefore, it is possible that "submitting the assignment" itself is the purpose of the assignment.

Furthermore, on the one hand, the results of the factor analysis for the questionnaire (1) suggest the following factors for the student's implementation of the assignment.

- Students understand the purpose and need for the assignment
- Students' interest in the subject matter is high
- Students know that the assignment will be graded

On the other hand, the factor analysis results for questionnaires (2) and (3) suggest the following factors that prevent students from performing the assignments.

- Lack of time to complete the assignment
- The assignment is too difficult for students

These suggest that five factors affect students' performance of the assignments. The following five ways of supporting students to promote the implementation of their assignments can be identified from the above five factors.

- Specify the purpose of doing assignments
- Conduct the class in a way that attracts interest
- Clarify the relationship to grades
- Allow sufficient time for submission / Give time estimates
- Adjust the difficulty level based on the student's grade

Among these, "Specify the purpose of doing assignments" is particularly effective because it is consistent with the students' attitudes in the submission group, and it is easy for professors to provide support.

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Examination of Change in Perception Toward Virtual Medical Education After COVID-19 Pandemic in the U.S. Using Twitter Data

Hyunchang (Henry) Moon
College of Education
Texas Tech University
hyunchang.moon@ttu.edu

Seungman Kim
College of Education
Texas Tech University
seungman.Kim@ttu.edu

Jaehoon (Jason) Lee
College of Education
Texas Tech University
Jaehoon.lee@ttu.edu

Jongpil Cheon
College of Education
Texas Tech University
jongpil.cheon@ttu.edu

Abstract

COVID-19 introduced a large percentage of the world's students and teachers to virtual learning. The purpose of this study was to examine the changes in perception toward virtual medical education during the pandemic in the U.S. Twitter data (tweets) associated with the virtual educational experience in the medical fields was obtained. Three analysis methods (topic modeling, sentiment analysis, and longitudinal cluster analysis) were adopted for the study. Across the selected topics, we found differences in conversations in virtual medical education fields. The topical patterns by frequency, polarity, and subjectivity identified the needs of those involved in virtual medical education and the areas that need to be overcome to improve virtual learning. More findings and implications are further discussed.
Keywords: virtual medical education, twitter, pandemic, COVID-19

Introduction

The COVID-19 pandemic has been changing our world significantly. In this situation, many fields mostly get a negative impact, but some do not. Virtual education can be the second case. Under the severe restriction of contacting others to prevent the spreading of the disease, virtual education grabs a chance to be utilized in most educational organizations. Even people who did not favor virtual learning and did not have experience of it face the situation where there is no choice but to receive virtual learning. In this situation, they might be able to find positive

aspects of it. On the contrary, the probability of finding virtual education's problems that have not been detected also increases by the increment of the frequency of virtual learning. Remote work and virtual education are likely to continue, albeit less intensely than at the pandemic's peak. As the pandemic has brought the future to the present with communication, professional development, and technology in medical education, virtual learning may have influenced a shift in people's perception of medical education during the pandemic. This leads to examining the changes in perception of virtual medical education to identify a need to improve the quality of virtual medical education.

Literature Review

The pandemic has had profound impacts on medical education globally. One of the fields that has the greatest resistance toward virtual learning is medical education. Many medical schools have adapted to virtual classes by altering their real-time clinical exposure to online modes (Rose, 2020; Ferrel & Ryan, 2020). Some schools echoed concerns over clinical experience and assessment during these times because practice-based learning is the backbone of medical education. Inevitably, most medical students' clinical placements stopped, and learning in classrooms and laboratories was cancelled, leaving students to continue their studies remotely (Ahmed, Allaf, & Elghazaly, 2020; Ferrel & Ryan, 2020; Sahi, P. K., Mishra, D., & Singh, T., 2020). Medical professionals also have cancelled their training to cope with pressures from cases of COVID-19, which is considered fundamental in their education, training, and progression (Gill, Whitehead, & Wondimagegn, 2020; Rajab, Gazal, & Alkattan, 2020; Sandars & Patel, 2020).

The emergence of social media platforms can be traced back to 1996, but truly emerged in their modern form in the early 2000s (Singh, 2019). With platforms such as LinkedIn, Facebook, Twitter, Instagram, YouTube, and more, the number of worldwide users has jumped from almost a billion in 2010 to 2.62 billion in 2018 (McFadden, 2018; Singh, 2019). Social media platforms allow users to share knowledge simultaneously (Toprak v.d., 2009, pp.28-84). In this vain, social media opens up new possibilities to understand people's perception (Selwyn, 2007). Studies show that Twitter, which is one of the most commonly used worldwide social network tools, is used all around the world as the most chosen educational tool (Elavasky, Mislan, & Elavsky, 2011; Feliz, Ricoy, & Feliz, 2015; Junco, Heiberger, & Loken, 2010; Park, 2013; Rinoldo, Tapp, & Laverie, 2011; and Zainal & Deni, 2015). This research study was conducted to analyze the use of Twitter.

The worldwide COVID-19 pandemic crippled health systems and closed schools across the globe. This challenge makes educational organizations, educators, and instructional designers fall into problematic situations. As we move forwards, a COVID-19 generation of students and doctors need to continue their education and training. While pandemics have historically created challenges, identifying these challenges is the first step in converting them into opportunities.

Purpose of the Study

The pandemic has provided an opportunity to investigate whether learners or education providers in medical education have positive or negative perceptions, or whether there is a change in their perceptions for virtual learning. These investigations would allow us to identify their needs in virtual medical education, the reason why they do not favor virtual learning can be

analyzed, and the way to break through the problems. This study, thus, aims to examine the changes in perception toward virtual medical education after COVID-19 pandemic in the U.S. using tweets. This study has the following research questions: (a) What are the topical patterns in tweets related to virtual medical education over the past five years?; and (b) What are the trajectories in the characteristics (i.e., frequency, polarity, and subjectivity) of the topical patterns on virtual medical education?

Analytical Framework

Given the nature of our research questions, the study adopted a quantitative research method to yield a comprehensive analysis. In this study, the change in perception toward virtual education of stakeholders in medical education organizations in the U.S. were examined by Twitter data (tweets). The topic modeling method is useful to find how many topics in the collected tweets dataset and what do the topics represent. Cross-validation is a type of model validation technique for assessing how the results of a statistical analysis generalize to an independent data set. Each topic can be allocated to individual tweets, and the change in the number of tweets in the topics for each year can be inspected to find the change in people's interest. Also, sentiment analysis is useful to find the changes in people's polarity and subjectivities in a period. The segment analysis allows to systematically identify, extract, quantify, and study affective states and subjective information. Lastly, longitudinal cluster analysis is useful to find groups that share trends among trajectories of the topics over a certain time.

Method

Data Collection

In order to extract tweets that represent the perception toward virtual medical education, predefined keywords that can be categorized in four primary ways (virtual: 10, medical: 30, education: 24, and region: US) and Twitter Premium API were used. Two software tools, Python 3.8 and Microsoft Visual Studio 2019, were used to execute this process iteratively for one year after the national emergency declaration for the COVID-19 pandemic (March 13th, 2020 - March 12nd 2021) and the period of four years precedent the declaration (March 13th, 2016 - March 12nd 2020). A total of 6,542 tweets over five years were collected.

Preprocessing

Before analysis, by following steps, the extracted dataset was cleaned to increase the clarity of the result. First, tweets that were too short thereby often meaningless (i.e., < 60 characters) and were therefore excluded. Second, using the NLTK library (Bird et al., 2009) in Python, stop words such as pronouns, prepositions, and postpositions were filtered out. Finally, 'term frequency-inverse document frequency (tf–idf) was used to select words that frequently occur but are not shared across all tweets.

Data Analysis

Three primary analysis methods, the Latent Dirichlet Allocation (LDA; Blei, Ng, & Jordan, 2003), sentiment analysis, and longitudinal cluster analysis, were employed to examine

the changes in perception of stakeholders of medical fields toward virtual education after the COVID-19 pandemic situation.

Latent Dirichlet allocation (LDA; Blei et al., 2003), so-called topic modeling, one of the unsupervised machine learning techniques, was employed to identify topics in a set of documents (e.g., tweets). The topic models (Grün & Hornik, 2011) package in R (R Core Team, 2020) and RStudio 1.3.1056 (RStudio Team, 2020) was utilized for LDA. As the initial stage of LDA, the optimal number of topics were determined (Zhao et al., 2015) using the ldatuning package (Nikita & Chaney, 2020). Figure 1 shows three different metrics of Griffiths (2004), Cao and Juan (2009), and Arun (2010). They all suggested 20—30 topics as optimally emerging in the tweets—i.e., with 20 - 30 topics, the Griffith value was maximized (approaching 1), and the Cao and Juan and Arun values were stabilized.

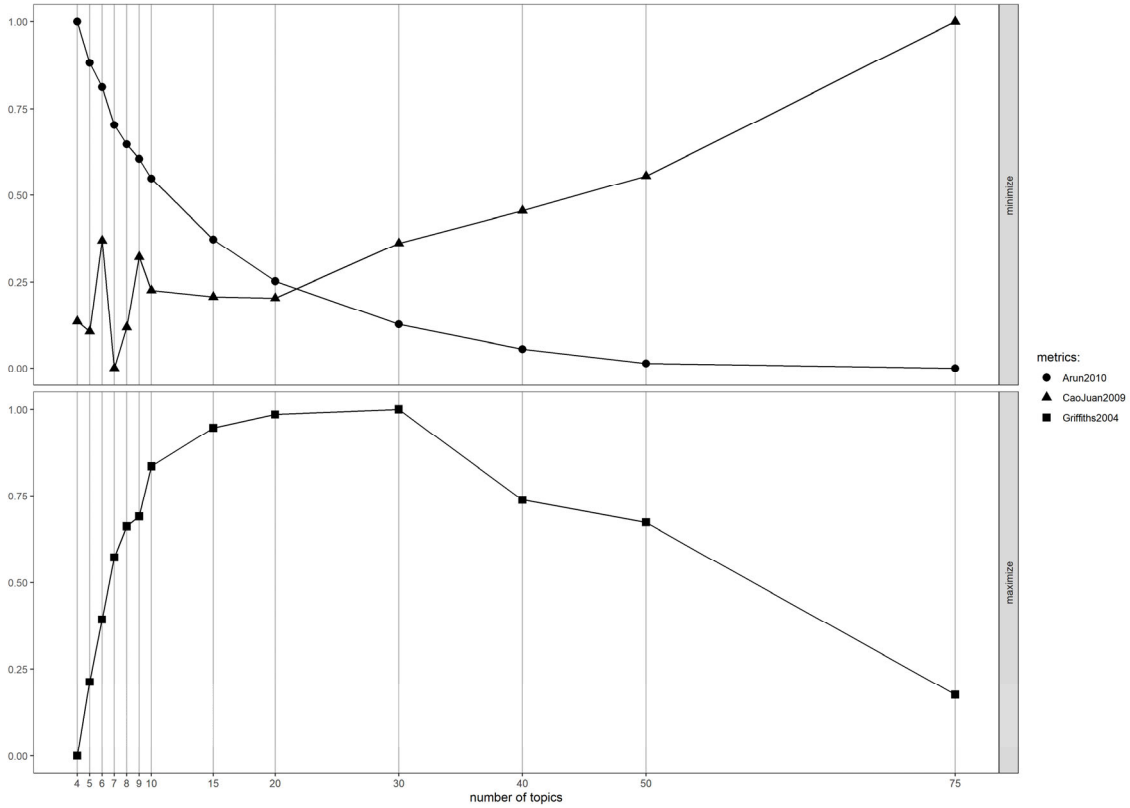

Figure 1. The optimal number of topics identified by different metrics

Sentiment analysis was conducted for finding the authors' emotional states using the TextBlob library in Python. Specifically, the tweets having a subjectivity value (range from 0 to 1) greater than or equals to .50 were classified as subjective otherwise categorized as objective. The polarity and subjectivity were estimated for each tweet. Polarity has ranged from –1 to +1, and the tweets were classified by the polarity value— negative (polarity ≤ –0.30), neutral (–0.30 < polarity < 0.30), and positive (polarity ≥ 0.30).

The longitudinal cluster analysis, an unsupervised machine learning technique, could find groups that share trends (such as increasing, decreasing, steady) among trajectories of the topics over a certain time without human intervention. When there are too many objects to be compared, it is more effective and easier for interpreting that grouping objects to a smaller

number of groups according to characteristics (trends) and compare the groups rather than directly comparing each object; therefore, in this study, longitudinal cluster analysis was hired to find clusters of the topics that share unique joint-trajectories across the 5-years. The changes in three factors 1) frequency of the topics, 2) averages of polarities, and 3) average of subjectivities over the 5-year period were used to group topics, using kml (Genolini et al., 2013) package.

Findings

LDA found 30 topics from the extracted tweets, but only 24 were clearly interpretable and relevant to the study of those topics; therefore, the remaining 6 topics and their words were excluded from the analysis. The 24 selected topics were labeled as remote learning (topic 1), support (topic 2), virtual program (topic 3), family support (topic 4), nursing program (topic 5), social distance and safe (topic 6), Benefits (topic 7), anatomy class (topic 8), mental health (topic 9), negative feeling (topic 10), professional development (topic 11), clinical study (topic 12), course assignment (topic 13), registration (topic 14), virtual meeting (topic 15), virtual medical lab (topic 16), quality of education (topic 17), stakeholders (topic 18), gratefulness of online learning (topic 19), working from home(topic 20), nursing classes (topic 21), hybrid modality (topic 22), virtual commencement (topic 23), medical training/certification (topic 24).

From the sentimental and longitudinal cluster analyses, four clusters are identified with 19 selected topics using their trajectories for the 5 years. The longitudinal clustering algorithm found three, four, and two unique trajectories of topics from the frequencies of the topic, polarities, and subjectivities across the 5-years, respectively (see Figure 2, 3, & 4).

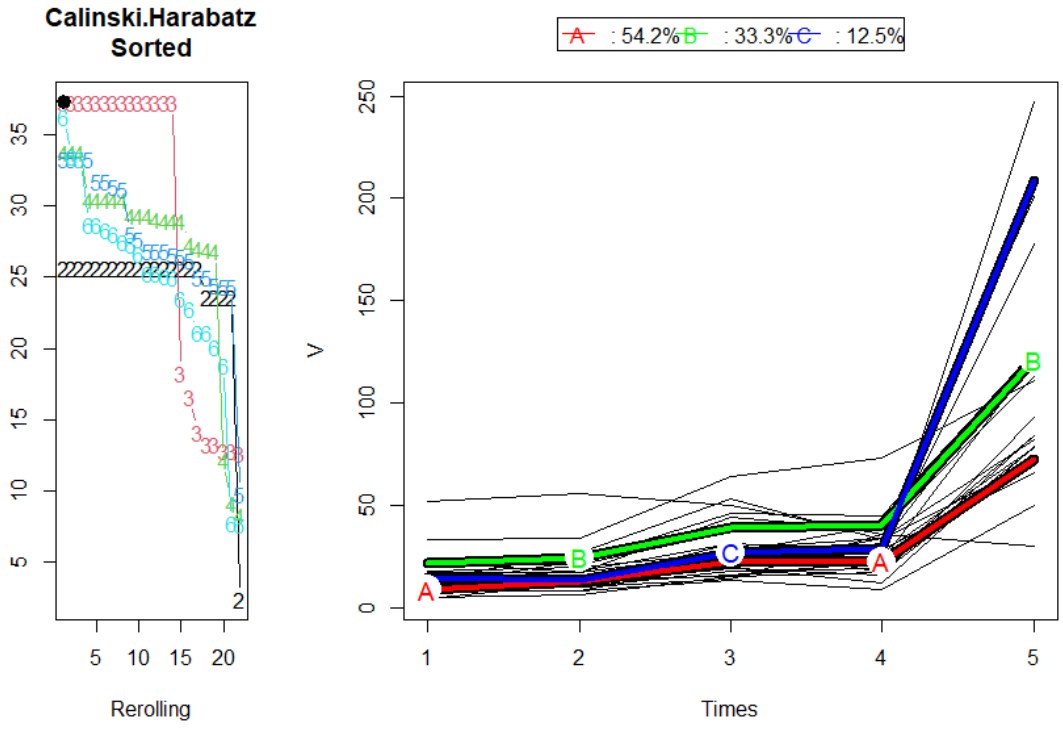

Figure 2. Graphs for results of longitudinal cluster analysis by frequency

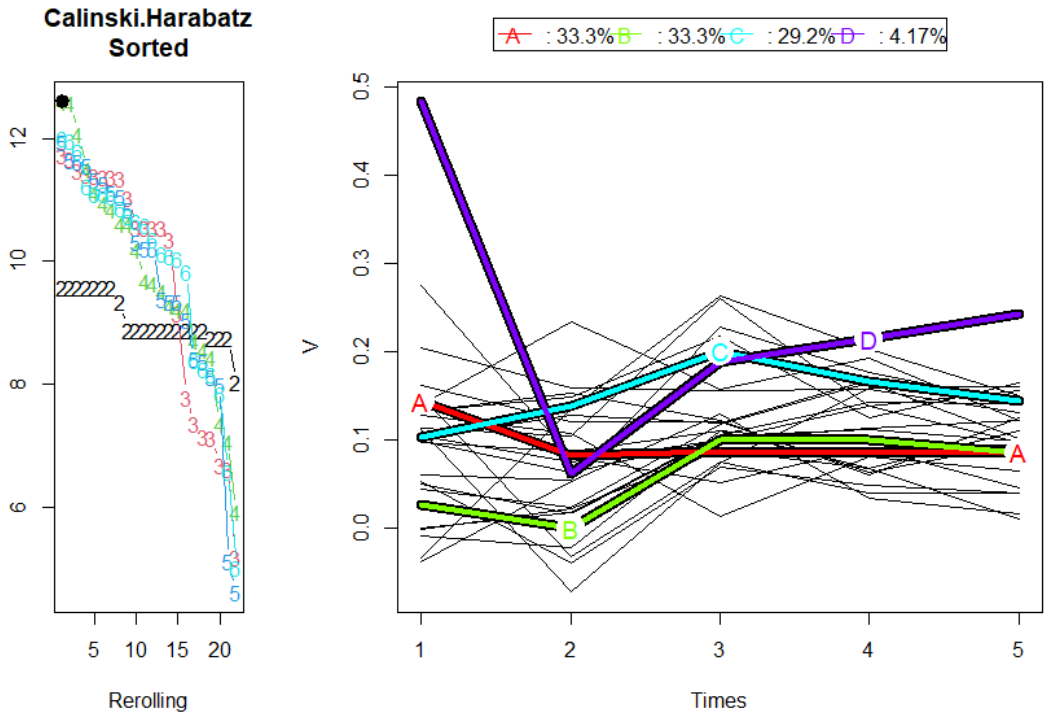

Figure 3. Graphs for results of longitudinal cluster analysis by polarity

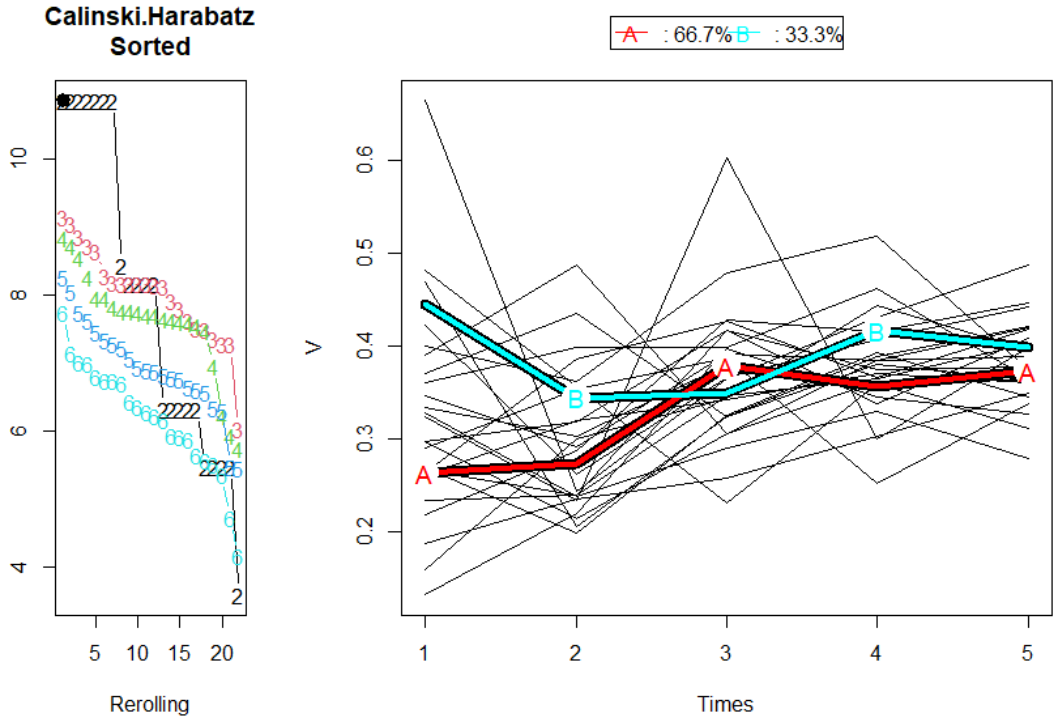

Figure 4. Graphs for results of longitudinal cluster analysis by subjectivity

In frequency, cluster A (54.2%) showed the tendency of increasing frequency after the pandemic but compared to other clusters, the slope was gradual. As the graph shows, cluster B (33.3%) reported medium steeper increasing trend after the pandemic. The most dramatic trend—an exponential increase after the pandemic—was displayed in cluster C (12.5%).

In polarity, the algorithm found four clusters. Cluser A (33.3%) shows mostly steady polarity around 0.1 after dropping in 2017, which means the topics belong to cluster A had been written in a neutral mood in the period. Cluster B (33.3%) and C (29,2%) displayed slight decrease tendencies after 2020, so it can be said that there were a few more negative tweets on the topics after the pandemic. However, cluster C has noticeably more positive tweets compared to cluster B during the whole period. Cluster D showed a very unique pattern that it was rapidly dropping in 2017, after then has been increasing regardless of the pandemic. Thus, it might be guessed that something probably happened in 2017 that influenced in the negative direction to cluster D which has only one topic, gratefulness about online learning (topic 19). However, after 2017, the mood has been moving toward a positive direction.

In subjectivity, only two clusters were suggested. As through the pandemic, cluster A (66.7%) showed a slight increase pattern that means people wrote more subjective tweets, and cluster B (33.3%) illustrated the opposite result (more objective viewpoint). All identified clusters by three factors and their topics are shown in Table 1. The cluster names were arbitrary assigned by the algorithm. For instance, Cluster A found by frequency is different from cluster A identified by polarity.

Table 2. *Identified clusters and their topics by frequency, polarity, and subjectivity.*

Cluster	By frequency (Topic #)	By polarity (Topic #)	By subjectivity (Topic #)
A	professional development (11) clinical study (12) course assignment (13) registration (14) virtual meeting (15) virtual medical lab (16) quality of online course (17) stakeholders (18) gratefulness about online learning (19) working from home (20) hybrid modality (22) virtual commencement (23) medical training/certification (24)	remote learning (1) benefits (7) anatomy class (8) clinical study (12) virtual medical lab (16) quality of online course (17) working from home (20) medical training/certification (24)	remote learning (1) support (2) virtual program (3) nursing programs (5) benefits (7) anatomy class (8) mental health crisis service and support (9) professional development (11) clinical study (12) course assignment (13) registration (14) virtual meeting (15) virtual medical lab (16) working from home (20) virtual commencement (23) medical training/certification (24)
B	support (2) virtual program (3) family support (4) nursing program (5) benefits (7) anatomy class (8)	virtual program (3) social distance and safe (6) mental health crisis service and support (9) negative feeling (10) course assignment (13) stakeholders (18)	family support (4) social distance and safe (6) negative feeling (10) quality of online course (17) stakeholders (18) gratefulness about online learning (19)

	negative feeling (10) nursing classes (21)	nursing classes (21) hybrid modality (22)	nursing classes (21) hybrid modality (22)
C	remote learning (1) social distancing and safe (6) mental health crisis service and support (9)	support (2) family support (4) nursing programs (5) Professional development (11) registration (14) virtual meeting (15) virtual commencement (23)	-
D	-	gratefulness about online learning (19)	-

Discussion and Implications

The study examined the changes in perception of medical fields toward virtual education on tweets for the last five years including the COVID-19 pandemic period. Across 24 selected topics, major themes were identified in conversations in virtual medical education fields. First, medical education schools were unprepared and ill-equipped to handle the overwhelming obstacles and immediate needs (e.g., new planning, support, accessibility, mental health crisis, registration). Second, COVID-19 has accelerated reshaping of medical education (e.g., leadership, safe learning environment, clinical study, group activities, virtual lab, quality of online course, hybrid). Third, virtual medical education was not only challenging for the last 12 months but they also look to the future possibilities (e.g., benefits, professional development, experiential learning).

The results from the sentimental and longitudinal cluster analyses identified clusters and their topics by frequency, polarity, and subjectivity. The trajectories information over the past five years helps explain a need in virtual medical education and the reason whether they favor virtual learning or not. Virtual education has grown rapidly since the pandemic. Medical education has also seen a rapid increase over the past year. As formal medical education had to move to remote format for social distancing, mental health crisis also increased (Cluster C). In order to reduce these side effects, many supports have also been increasing (Cluster B).

The polarity of the tweets over the period shows that there were more positive statements, especially since the pandemic of gratefulness for virtual education has seen the highest rise in positivity on average. Conversely, there was a slight decline in other clusters (Clusters A, B, & C, indicating many difficulties and challenges for virtual medical education.

Lastly, the subjectivity. Subjective statements about virtual medical education generally represent personal opinions, feelings, or judgments, while objective ones represent factual information. Both clusters identified were found to be subjective due to the nature of expressions on social media. In the past, there was a large difference between Cluster A and B, but recently the gap has been gradually narrowing. Social safety, negative emotions, and family support have been expressed a more subjective expression on their tweets. On the other hand, as for the general views of virtual medical education, the effort was reflected by increasing objectivity during the period (Cluster A).

Virtual education continues, although less intense than at the peak of the pandemic. We hope that this study contributes to broadening our understanding of virtual medical education. By understanding their needs for virtual medical education, we expect to be connected in a concrete way to how to solve problems in virtual medical education.

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Investigating Cognitive Presence Patterns and Content Knowledge Levels in Asynchronous Online Discussions (AODs): A Longitudinal Study

Zhijuan Niu
School of Education, Syracuse University
230 Huntington Hall
Syracuse, NY 13244
zhniu@syr.edu

Tiffany A. Koszalka
School of Education, Syracuse University
230 Huntington Hall
Syracuse, NY 13244
takoszal@syr.edu

Qi Wu
School of Education, Syracuse University
230 Huntington Hall
Syracuse, NY 13244
qwu16@syr.edu

Abstract

Students construct knowledge during asynchronous online discussions (AODs). Discussion postings show students' cognitive presence (CP) patterns and content learning levels. The purpose of this longitudinal field observation study was to investigate the patterns of, and relationships among, the same cohort of graduate students' cognitive presence and content knowledge level demonstrated within and across the AODs in two consecutive courses over two semesters. Content analysis of online discussion postings, descriptive and correlational statistics were used to analyze data. The results indicated that the exploration was the most active phase that emerged in AODs, followed by the integration, triggering event, and resolution. There was a significant change in the integration phase of CP and content knowledge levels over time. Moreover, the results yielded significant relationships among CP patterns and content knowledge levels. The findings have important implications theoretically in confirming the CP patterns that emerged in AODs and practically by identifying the dynamics of each of the CP phases and their associations with content learning.

Keywords: Asynchronous Online Discussions; Cognitive Presence; Content Knowledge

Introduction

For decades, asynchronous online discussions (AODs) have been used as a social, collaborative learning environment in higher online education. Social constructivism views learning in such an environment as an act of constructing knowledge through socially informed cognitive engagement where participants share, debate, listen, reflect, and confirm their knowledge in the context of communicating with others (Jonassen et al., 1995; Johnson & Johnson, 1996; Vygotsky, 1978).

AODs are primarily designed to prompt learners to engage cognitively to enhance their content learning through social interactions. Current research in AODs often studies cognitive engagement using the cognitive presence (CP) construct of the Community of Inquiry (CoI) framework to examine students' learning process (Garrison et al., 2000). CP defines ways that students mentally navigate the social learning process; how they consider new problems, seek to develop understanding, and share understanding with their learning community during the process of validating and modifying their understanding (Akyol & Garrison, 2011).

In AODs, students co-construct their knowledge through iterative interactions and collaborations with others in their learning community (Hew & Cheung, 2003; Joksimovic et al., 2014). Such collaborative interactions can prompt co-regulation and metacognition among those participating in communication events, activating, and enhancing cognitive processing within the individual and across the community (Jonassen et al., 1995).

AODs can activate a student's cognitive processing beyond surface learning into deeper learning through CP (Garrison et al., 2001). "In AODs, learners who have different ideas and prior experiences share their thoughts, read, reflect on, and react to others' postings using their cognitive processes (behavior) to collaboratively create a richer understanding of the content topic at hand (learning)" (Koszalka et al., 2021, p, 3). Such interactions represent higher-order thinking (Anderson et al., 2001) and suggest behaviors that indicate the construction of deeper content knowledge (Akyol & Garrison, 2011; Garrison et al., 2001; Jonassen et al., 1995).

However, studies have shown that learning expectations for multiple CP phases and deeper content learning in AODs are not always achieved (Chen et al., 2019; Koszalka et al., 2021; Koszalka et al., 2019). Researchers have examined factors that may contribute to exploration activities during cognitive engagement processes to understand these deficiencies. But few studies were found that directly studied the relationships among cognitive presence (CP) and level of content knowledge demonstrated in AODs. Koszalka et al. (2021) recently suggested a significant relationship among levels of idea exchange, content focus, and surface/deep learning in AODs, but only studied this phenomenon in several one-time, short AOD sessions, not directly investigating CP. Since individual cognitive engagement can result in different cognitive development outcomes, e.g., levels of demonstrated content learning (Jonassen et al., 1995; Koszalka et al., 2021), it is important to unpack the relationships between CP and content learning levels. And how learners enter deep content learning during AODs with the development of CP processes and whether they maintain or build different patterns and levels of deep learning in subsequent AOD experiences are lack of study. Therefore, it is necessary for us to explore how CP presences and content learning changes over time. Such studies may inform design strategies for conducting effective AODs.

The current study focused on studying the relationships among each phase of CP (trigger, exploration, integration, resolution) and the level of content learning demonstrated within the same cohort of students, across two consecutive core courses, offered over two semesters

(longitudinal study). We hope to identify whether students who engage in various surface and deep learning strategies during AODs in an early course benefit from this initial experience and continue to engage in deeper learner behaviors in subsequent AODs. These questions suggest looking at longitudinal patterns of cognitive presence and learning levels across multiple, sequential AODs within and across courses. Therefore, the present study aims to add our understanding of the relationships between CP and depth of content learning and how these patterns form (or not) longitudinally.

Research Questions

The current study involved analyzing the AODs transcripts. We collected the convenient data from the same cohort of 12 graduate students from two courses. These students were pursuing a master's degree in instructional design. Before taking the two courses, all students have had experience in online courses. IRB exempt status was granted for this study. Female and male students were 2 (16.7%) and 10 (83.3%), respectively. The average age of the cohort is 44. All participants have military experience. The average length of their military service is 22 years. Two of them are veterans, and the rest of them are active-duty service members.

Students' CP patterns were coded and examined using Garrison et al.'s (2000) CoI framework. Content knowledge levels were identified and analyzed using Anderson et al.'s (2001) updated version of Bloom's taxonomy and previously developed protocols from Koszalka et al. (2021). There were three research questions:

1. What patterns of cognitive presence and content knowledge levels emerge within and across the AODs?
2. How do the cognitive presence patterns and content knowledge levels of the same cohort of students change (or not) over time in the two courses investigated?
3. Is there any significant relationship between cognitive presence patterns and content knowledge levels of the same cohort of students across multiple AODs?

Method

The transcripts of 276 postings from Course A and 273 postings from Course B were retrieved from the Blackboard LMS, downloaded, cleaned, and saved in the qualitative data analysis software MAXQDA before coding. There was no information related to students' identities. The cohort of students participated in the AOD of Course A in the fall semester and then participated in the AOD of Course B in the spring semester of the same academic year.

We applied a quantitative content analysis approach, transferring students' postings into quantifiable codes. We followed the steps of a content analysis suggested by Neuendorf (2017, P. 67-69):

Step 1. We collected data that fit our research purpose

Step 2. We selected a single meaning as the unit of analysis.

Step 3. The two coders in our team independently divided each posting into one meaning and then dismissed the inconsistencies through a discussion.

Step 4. The two coders coded the meanings with two separate existing coding frameworks. The first is cognitive presence from Garrison et al. (2001), and the second is content level from Koszalka et al. (2021). The first four categories of the coding framework focused on

the cognitive engagement process in the course content. The last two categories focused on the level of content learning (surface or deep) demonstrated in students' postings.

Step 5. The two coders coded the first 200 meanings of the AODs for checking the inter-rater reliability.

Step 6. The two coders discussed the inconsistencies, re-coded the 200 meanings to improve inter-rater reliability, and finished coding the rest of the meanings in the AODs.

Finally, relying on the numerical data in terms of the codes, we run descriptive and correlational statistics through the SPSS software for finding the patterns (RQ1), changes (RQ2), and relationships (RQ3).

Results

RQ1. What patterns of cognitive presence and content level emerge within and across the AODs?

Descriptive statistics were generated to understand the patterns. Through the content analysis, we produced 1630 meanings (n=1630) hidden in the postings of the AODs.

While all the four phases of cognitive presence appeared in the meanings, the ratios of their frequencies were different. The exploration phase was identified from 1382 meanings out of 1630, having the highest ratio (84.8%) among the four phrases. The integration phrase took second place with 349 meanings. Only 152 and 51 meanings correspondingly include the triggering event phrase and the resolution phrase.

The proportions of the content levels are only slightly different compared to the proportions of CP. 947 meanings were coded as content low, while 664 meanings were coded as content high. Only 19 meanings existed for social purposes and did not have any content relating to the discussion topics.

RQ2. How do the cognitive presence patterns and content knowledge levels of the same cohort of students change (or not) over time in the two courses investigated?

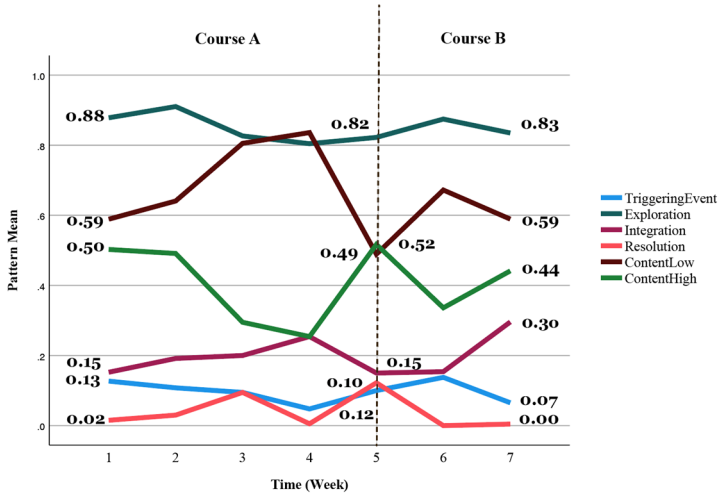
To better understand whether and how the cohort's patterns change over time in the two courses, we also coded each meaning of the AODs with the posted week as a time label. The AOD in Course A lasted five weeks, and the AOD in Course B lasted two weeks. The number of generated meanings from Week 1 to Week 7 are 197, 167, 190, 189, 180, 247, and 460. These numbers clearly demonstrated a tendency for the same cohort of students to become more engaged in the last two weeks as they created more meanings.

Figure 1 shows the changes in the CP and content level in the AODs over time. When we observed the changes from a seven-week range, both the cognitive presence and content level fluctuated over time and thus did not show a consistent tendency. With low mean values, both the triggering event and resolution phrases are stated at low mean values and fluctuate less than other phrases. This indicated that students rarely played as an ice breaker (i.e., the role triggering a new topic) and problem-solver (i.e., the role posing a solution to a problem) in any time spot of their AODs. Comparatively, the mean value of the exploration phrase stayed high all the time, implying that students were more likely to play the explorer (i.e., the role providing pieces of content) and stick to this role during the whole AOD process. The tendency of the integration phrase fluctuated less in the first five weeks, but it showed a sudden increase in the last two weeks. This could suggest that after finishing the AODs of Course A, the cohort of the students

promoted their ability to integrate pieces of information into a whole new meaning unit as they were more willing to play the role of synthesizer.

The tendencies of content level fluctuated more fiercely compared to the cognitive presence tendencies. We were surprised that the two tendency lines of the content low and content high were highly symmetrical and even looked like mirror effects. It implied a strong correlation effect between the content low and the content high. In the weeks of Course A, the content low tendency was leveling up in the first three weeks, peaked in the fourth week, and then fell sharply in the last week. Oppositely, the content high tendency was leveling down in the first weeks, reached a valley in the fourth week, and then went back to the situation close to the start point.

Figure 1. AOD Patterns Over Time



RQ3. Is there any significant relationship between cognitive presence patterns and content knowledge levels of the same cohort of students across multiple AODs?

Inferential statistics were generated for understanding the relationships among the cognitive presence phrases and content knowledge levels. The matrix below (Table 1) shows the significant correlations. The content high variable was strongly and significantly correlated with the content low variable negatively ($r=-.836$, $p<0.01$). It could indicate that students rarely invested their endeavors in creating meaning with both content levels in the AODs. Another strong and significant correlation occurred between the exploration and integration phase variables ($r=-.674$, $p<0.01$). It revealed that the exploration phrase and integration phrase hardly co-existed in a single meaning of the AODs. In other words, students tended to stay with either a deductive phase (i.e., exploration) or an inductive phase (i.e., integration) rather than involve both when they created an AOD meaning.

Some correlations were found comparatively weak but significant. It seems that the resolution phase of CP was slightly correlated with the content low variable negatively ($r=-0.09$, $p<0.01$), but it was slightly correlated with the content high variable positively ($r=0.081$, $p<0.01$). It suggested that in the resolution phase, students preferred to stay at the content high level. The exploration phase variable was positively correlated with the content high variable ($r=0.08$, $p<0.01$). It suggested that when students explore information for building the meanings of the AODs, they tend to use the content with their higher levels of thinking (e.g., analogy, comparison).

Regarding the time variable, the data ($r=-0.056$, $p<0.05$) indicated that content level might increase as time went on. Furthermore, students seemed to become more cognitively engaged in the integration phase ($r=0.083$, $p<0.01$) and less cognitively engaged in the resolution phase ($r=-0.063$, $p<0.05$) when the AODs were closer to the end.

Table 1. Correlation Matrix for All the Patterns

		ContentLow	ContentHigh	TriggeringEvent	Integration	Exploration	Resolution	Time
ContentLow	Pearson Correlation	1	-.836**	-.034	-.021	-.007	-.090**	-.056*
	Sig. (2-tailed)		.000	.166	.394	.786	<.001	.025
	N	1630	1630	1630	1630	1630	1630	1630
ContentHigh	Pearson Correlation	-.836**	1	.005	.012	.080**	.081**	-.018
	Sig. (2-tailed)	.000		.851	.638	.001	.001	.456
	N	1630	1630	1630	1630	1630	1630	1630
TriggeringEvent	Pearson Correlation	-.034	.005	1	-.044	-.046	-.046	-.040
	Sig. (2-tailed)	.166	.851		.076	.062	.066	.105
	N	1630	1630	1630	1630	1630	1630	1630
Integration	Pearson Correlation	-.021	.012	-.044	1	-.674**	-.016	.083**
	Sig. (2-tailed)	.394	.638	.076		<.001	.506	<.001
	N	1630	1630	1630	1630	1630	1630	1630
Exploration	Pearson Correlation	-.007	.080**	-.046	-.674**	1	-.071**	-.035
	Sig. (2-tailed)	.786	.001	.062	<.001		.004	.153
	N	1630	1630	1630	1630	1630	1630	1630
Resolution	Pearson Correlation	-.090**	.081**	-.046	-.016	-.071**	1	-.063*
	Sig. (2-tailed)	<.001	.001	.066	.506	.004		.010
	N	1630	1630	1630	1630	1630	1630	1630
Time	Pearson Correlation	-.056*	-.018	-.040	.083**	-.035	-.063*	1
	Sig. (2-tailed)	.025	.456	.105	<.001	.153	.010	
	N	1630	1630	1630	1630	1630	1630	1630

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Discussion

Our analysis of the first research question suggested that the exploration phase was the most active in AODs, followed by the integration, triggering event, and resolution. The highest ratio of exploration frequencies and the lowest ratio of resolution frequencies in AODs is consistent with previous research (Chen et al., 2019; Garrison et al., 2001; Meyer, 2003; Vaughan & Garrison, 2005). Some previous studies pointed out that it was difficult for students to reach the integration phase (Akyol & Garrison, 2008; Garrison, 2007; Kanuka et al., 2007; Vaughan & Garrison, 2005), but in this study, the integration phase is the second most active phase emerged in AODs. This finding aligns with Akyol and Garrison's (2011) study, revealing that the integration phase is active (Akyol & Garrison, 2011). The different results on cognitive presence patterns that emerged in AODs might be explained by different instructional designs of courses, including types of prompt questions (Chen et al., 2019; Garrison, 2007) and duration of AODs. The prompt questions for causes seeking and problem-solving are more likely to facilitate students to connect and synthesize ideas to construct their meanings and provide solutions, that is, to reach the integration and resolution phase of cognitive presence. The length of AODs also can affect students to achieve the integration and resolution phase. The longer students participated in AODs, the higher the possibility of reaching the integration and resolution phase. As for the content knowledge levels, the previous study, which explored the evidence of student content learning levels in a single course, showed that students' content-low postings were dominant in AODs (Koszalka et al., 2021), which is consistent with our study.

Our analysis of the second research question suggested that both cognitive presence patterns and content knowledge levels could change over time. Among the cognitive presence patterns, integration and resolution phases fluctuate a lot more than the other phases. Both the triggering event and exploration were at the highest levels at the beginning of the course weeks, and then there was a decreasing trend, finally going back to a higher level during the late weeks. Both the integration and resolution reached the highest levels during the mid and late course weeks and then presented a decreasing trend. These findings highly align with Sezgin's (2020) study. However, Sezgin (2020) conducted their study only in a single seven-week online course. Since this longitudinal study focused on changes over time in two courses across two semesters, something unique we found about the changes was that integration was the only phase of cognitive presence increased in the second course, which might be explained by the type of discussion questions and time. Students are more likely to reach the integration phase with more structured questions, and they can better integrate ideas from different sources with practice and efforts through AODs (Akyol & Garrison, 2008; Sezgin, 2020). For the content knowledge levels, we found that there were more content-low postings during the early weeks in which students tended to focus on sharing facts, a summary of reading materials, and their general understanding of the discussion topics. As time goes by, students gradually connect their understanding of the discussion topics with their personal experiences to demonstrate higher-order thinking skills.

Our analysis of the third research question suggested the correlations between cognitive presence patterns and content knowledge levels. Such correlations may enlighten the instructional design of AOD in multiple aspects. First, the negative correlation between the content low variable and content high variable indicates that students tend to stay at a single content level (i.e., low or high) when constructing an independent meaning in the AOD. The correlation between the exploration and integration phases demonstrates a similar pattern: students focus on only one cognitive presence phrase when they construct meaning. Therefore, the instructors may need to require or encourage students to construct multiple meanings in a posting so that multiple content levels and phrases of cognitive presence can occur in the AOD. A tested instructional approach to making this happen is to design structured prompts for eliciting diverse meanings in a single posting (Darabi et al., 2013). Structured prompts often include sequential questions requiring students' responses in different cognitive or content levels (Darabi et al., 2011). A group of researchers has found that structured prompts would lead to the robustness of meanings with various cognitive learning indicators in the AODs (Darabi et al, 2011; DeNoyelles et al., 2014; Lee 2012). Second, both the exploration phrase and resolution phrase were significantly correlated with the content high variable. It suggests that if students are expected to engage in the AODs cognitively, they may need to equip their high-level content learning skills, such as comparing different concepts and creating real examples. The study conducted by Koszalka et al. (2021) involved a series of pre-work activities prior to the AODs. In the pre-work activities, students had the chance to read the assigned content and practice their high-level content learning skills by reflecting on some scaffolded questions. The result proved that students were more cognitively engaged in the AOD after taking the pre-work activities. Thus, preparing students for some high-level content learning skills in advance can benefit students' cognitive presence in the AOD.

Conclusion

The research findings indicate that the exploration was the most active phase in AODs, followed by the integration, triggering event, and resolution. There was a significant change in the integration phase of CP and content knowledge levels over time. Moreover, the results yielded significant relationships among CP patterns and content knowledge levels. To encourage multiple CP phases and achieve deeper content levels in AODs, the instructors may need to require students to construct multiple meanings in a posting. For example, provide specific participation guidelines, design a timely feedback system, use structured prompts to elicit diverse meanings, or prepare students some high-level content learning skills in advance through well-designed pre-work activities. Future research may include but is not limited to the following list of potential empirical research: 1) Collect discussion transcripts in a longer time range (e.g., five years) to examine students' CP patterns and content learning levels demonstrated in AODs; 2) Compare the CP patterns and content learning levels of military students with non-military students to examine if students' characteristics influence their performance; 3) Integrate self-reported surveys and interviews to triangulate the findings of content analysis.

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The Historical Development of Deep Learning and Its Research Trend: A Literature Review

Hongchao Peng1, Jiabin Zhao1, Shanshan Ma2
(1.East China Normal University, 2.San Diego State University)

Abstract: Deep learning has recently received unprecedented attention from governments, schools, social institutions, and the media. The puspose of this study is to present an in-depth understanding of relevant research published in top-tier journals from 1976 to 2019 through a systematic review method.

The results reveavled: (1) four phases of deep learning research: dormant period, germination period, emerging period and rapid period; (2) the deep learning research is concerned more about process, little discussion on flexibility; (3) the concept shifted in two directions, one is from the pursuit of understanding to the pursuit of transfer and the other is from the focus on process to the focus on outcomes. Based on the findings, this study proposed a landscape to the concept of deep learning to deliever a full understanding of the deep learning and we suggest more research should focus on the problem of deep flexibility with the empowerment of smart classrooms.

Keywords: concepts evolvement; deep learning; learning architecture; literature review; research trend; smart classroom

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Influenced by the concept and framework of core literacy education, the deep learning movement has emerged. In addition, a series of education and teaching reforms triggered by information technology, especially AI technology, deep learning has once regained the wide attention of the academic community and the general public, especially at the time when machine defeated Lee Sedol, the world champion of Go. Deep learning in education has received unprecedented attention and recognition from governments, schools, social institutions, and the media (Zhu, & Peng, 2017). Currently, deep learning now is extremely valued among the school leaders (Johnson et al., 2014), and the shift to deep learning has also become a long-term trend driving the application of educational technology (Freeman, Adams , &Cummins, 2017). How to promote students' deep learning and cultivate their deep learning abilities has been an increasing important topic for an education reform.

Deep learning is not a newly emerging concept. Since 1976 when it was first time proposed, deep learning has experienced more than 40 years ‘ development and evolution. While there is little discussion regarding how deep learning developed, how the concept evolved, what are the current research bottlenecks we might need to focus on and what are the potential solutions, this study is to explore those questions and hope to help scholars and teaching practitioners construct a

comprehensive understanding of deep learning and accurately grasp the orientation of deep learning research and development. By using a systamacti review method, this study deeply reviewed articles indexed in SSCI ranging from 1976 to 2019.

1.Literature Sources and Analysis Methods

According to the literature dispersion theory of most key literature is usually concentrated in a few core journals, this study uses the paper title names of "deep(er) learning, deep approach(es), deep strategy/strategies" to search articles indexed in SSCI on the Web of Science database. The obtained documents are selected according to the following selection criteria (Petticrew, &Roberts, 2006): a) not a duplicate article, b) the topic should be about education and teaching, c) the publication date is between 1976 and 2019. A total of 109 arctiles were included for the further analysis.

First, the trend of deep learning research popularity was explored using econometric analysis and visualized through social network centrality analysis. Content analysis was used for an in-depth understanding of the research bottleneck and possible solutions of deep learning. The social network centrality analysis was carried out according to the following steps: a) data cleaning (e.g., term unification); b) importing keywords of the literature into BICOMB2 software for a word frequency analysis; c) generating co-occurrence matrix through co-occurrence analysis of high-frequency keywords with word frequency greater than or equal to 3; d) importing co-occurrence matrix into UCINET6 software for the social network centrality analysis using the NetDraw tool.

2.The trend and status of deep learning

Content analysis results show that international scholars generally believe that the concept of deep learning was first proposed by Maton and Säljö in 1976, even though they did not use the term, deep learning. In fact, this term was gradually adopted after the 1990s, and the earliest user was the scholar Valerie Malhotra Bentz (1992).

2.1. The trend of deep learning research

Econometric analysis shows (see Figure 1) that deep learning has not been widely concerned by scholars until 21st century. Throughout the history of deep learning research, the trend of deep learning research has gone through four periods: dormant period, germination period, emerging period and rapid period.

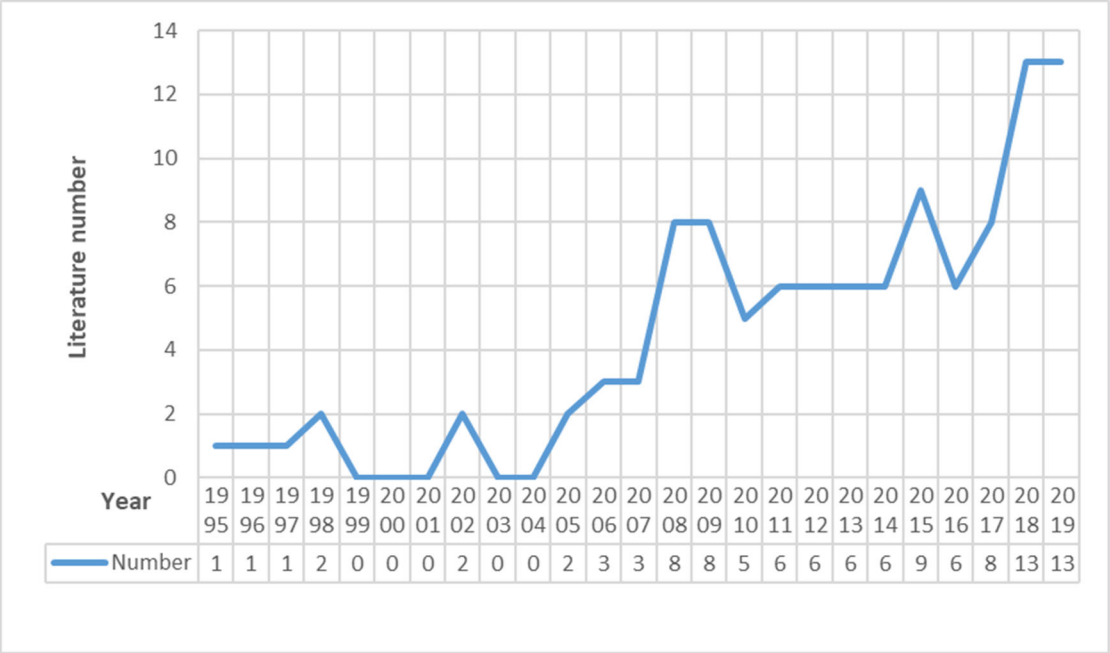

Figure 1 The annual Distribution of Deep Learning Literature

2.1.1.Dormant Period (1976-1995)

Since the birth of deep learning in 1976, deep learning has entered a long dormant period (see Figure 1). Although the literature of this period is not available in econometric statistics, we found there were still a group of scholars dedicated to deep learning research. John Biggs, professor of educational psychology, is one of the representatives. After in-depth research, they published many interesting results. The two most famous results are the SPQ Learning Process Scale and the SOLO taxonomy. The first one is to measure deep/superficial learning strategies and motivations. (Biggs, 1978), the second one is for measuring the results of deep learning (Biggs, &Collis, 1982). These two outcomes are still commonly used tools for scholars to measure the process and results of deep learning. In fact, after the 1970s, computers have gradually replaced some conventional tasks and manual tasks, and began to assist people in completing some unconventional tasks (Murane , &Levy, 1996), and promoted changes in in the enterprise's demand for talent structure: The demand for conventional skills has dropped sharply, and the demand for skills such as communication skills and expert thinking has soared (Conley, &Darling-Hammond, 2013). However, content analysis shows that deep learning at this time focuses more on the opposite of shallow learning (conventional memory, lack of deeply understanding, and just coping with exams), and it has not been in line with the above-mentioned social situation. This may be the reason why deep learning did not attract widespread attention and entered a long dormant period at this phase.

2.1.2.Germination Period (1995-2007)

Literature statistics show that in 1995, Hoon and others (1995) from Nanyang Technological University in Singapore applied deep learning strategies to high school chemistry classes for the first time to encourage students to visualize abstract concepts and explore the connections between

numerous chemical facts. Since then, deep learning research has entered a germination period, during which a small number of scholars' research and application results have appeared one after another. Content analysis shows that the concept of deep learning during this period was similar to the dormant period, still focusing on process. But in addition to exploring more ways/strategies that can promote deep learning, scholars have begun to explore formative evaluation and the support of various learning environments.

2.1.3.Emerging Period (2007-2016)

After entering the 21st century, various international organizations and countries around the world have devoted themselves to exploring what kind of new century talents should be cultivated. As a result, a variety of talent competency frameworks emerged. For example, the OECD released the DeSeCo competency framework in 2003, the European Union released the key competences for lifelong learning in 2006, and the P21 released the 21st century learning framework in 2007. Those frameworks had prompted the research of deep learning to enter the emerging stage. During this period, influenced by these key competency frameworks, an international wave of deep learning movement emerged: In 2010, the Hewlett Foundation of the United States initiated a 15-year deeper learning strategic plan (The William and Flora Hewlett Foundation, 2012). Asia Society and other ten institutions have also worked together to promote the spread of deep learning experimental schools throughout the United States (Alliance for Excellent Education, 2017). Moreover, the Victoria University in Canada launched a global deep learning initiative, cooperating with more than 1,000 schools in 10 countries to seek solutions for deep learning changes (NPDL, 2017). In 2015, the United States even issued a report to take deep learning as the national policy of education in the 21st century (National Association of State Boards of Education, 2015).

2.1.4.Rapid Period (2016 – present)

In addition to the fact that the United States regards deep learning as a national education policy, the event signaling the arrival of the rapid development period of deep learning is when the intelligent robot AlphaGo defeated the world go champion Lee Sedol in 2016. This event once increased the concern that machines would replace humans, and prompted scholars to reflect on questions such as "since humans can teach machines to learn deeply, why can't we teach children to learn deeply in school?". During this period, deep learning research has been improved in all aspects: from concept expansion, strategies testing, model construction, to mechanism exploration, evaluation development, and then to subject application. During this period, deep learning enabled by technology, especially intelligent technology, has become an emerging research trend. In particular, the release of the Core Competences for Chinese Student's Development in 2016 added a powerful fuel for deep learning research. Given this situation, Chinese Scholar Kekang He (2018) asserted that deep learning has regained the widespread attention of academia and even the general public (according to the data, the first attention occurred during the Rapid Period).

2.2.The status of deep learning research

Figure 2 shows the research status of deep learning formed by the analysis of social network centrality. The larger the box, the higher the centrality, and the distance between the boxes reflects the close relationship between keywords.

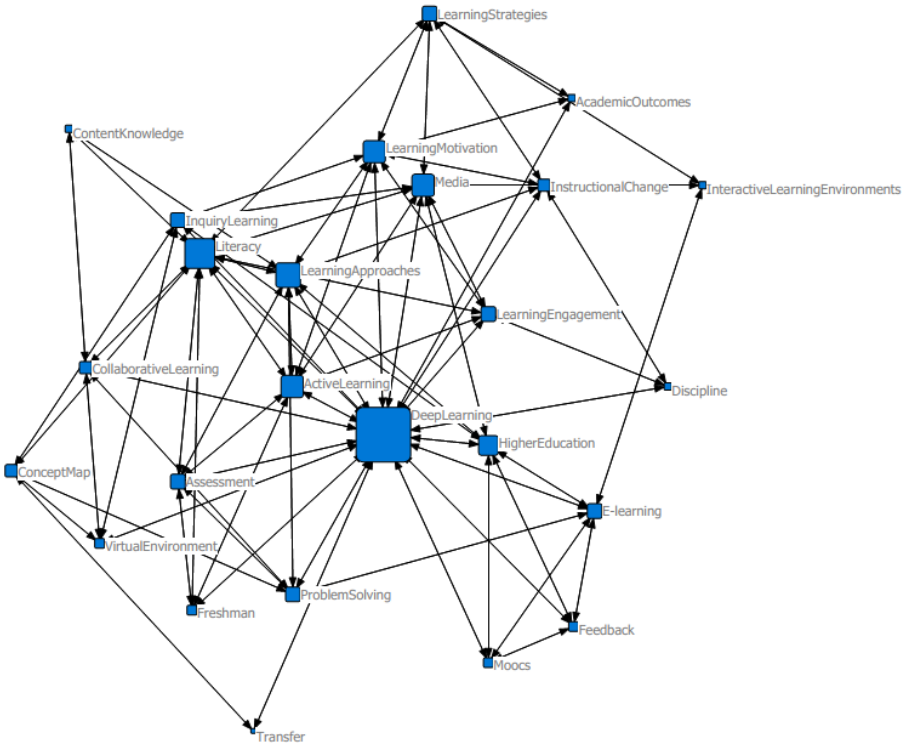

Figure 2 Community diagram of high-frequency keywords in deep learning literature

On the whole, the research of deep learning is biased towards promoting students' deep participation in learning and adopting advanced learning strategies. Specifically, In terms of deep participation learning, there is detailed research from the macro-participation culture to the micro-class participation (cognition, emotion, behavior) (Terrenghi et al., 2019; Gee et al., 2019). In terms of advanced learning strategies, scholars are committed to exploring various strategies to achieve deep learning, from peer teaching as a teacher to self-perception reflection (Nelson et al., 2014).. In terms of the development of high-level knowledge and skills, many literatures involve research on key compentencies such as creativity (Turvey, 2006) and critical thinking (Wang et al., 2015), while Figure 2 shows that it has a distant relationship with deep learning. In terms of transfer applications, there are few related studies, and the few existing mainly focus on the transfer of knowledge (Green et al., 2013; Nielsen, 2016): Figure 2 shows that transfer is on the edge of extreme remoteness confirms this conclusion.

3.The Concept Evolution of Deep Learning

At present, deep learning is more than a learning method used to understand basic knowledge, it usuallyrefers to learning strategies for obtaining advanced knowledge and its transfer.

3.1.The change of ideas

3.1.1.From pursuing understanding to pursuing transfer

In the early days, the deep learning proposed by Marton and Säljö (1976) aimed at learning approaches or strategies. Simply put, learning by understanding is deep learning, but learning by reproduction is shallow learning. Deep learning at this time is reflected at four aspects, they are

seeking meaning, connecting ideas, using evidence, and being interested in opinions. Shallow learning is mainly embodied in three aspects: information is memorized irrelevantly, learning is limited to the syllabus, and adopting minimal effort to avoid failure (Tait, & Entwistle, 1996). This kind of learning only generates a limited understanding, little connection between concepts. On this account, the famous scholar Ramsden (2003) believed that shallow learning is at best a quantity without quality (quantitative change), while deep learning is a cumulative quantity of quality (qualitative change).

It is easy to find that the goal of deep learning at this time is to understand, and the goal of shallow learning is to reproduce the test materials. Although shallow learning can produce superficial understanding, it is not one of its learning goals.

Since deep learning starts in a way of understanding and constructing meaning, people soon realized that it can lead to better transfer of knowledge and concepts (Van, &Schenk, 1984). After entering the 21st century and facing the ever-changing new situation, how to transfer what has been learned in the classroom to enable students to succeed in future work and life has become a new education challenge. Therefore, the purpose of deep learning has changed from understanding to transfer (i.e. learning for transfer), and understanding becomes the basis for deep learning to realize migration. The National Research Council of the United States has set the tone of deep learning as the process through which an individual becomes capable of taking what was learned in one situation and applying it to new situations (i.e., transfer), and the product of deep learning is transferable knowledge (National Research Council, 2012). This kind of knowledge includes not only the content knowledge of a certain field in the traditional sense, but also the knowledge of how, why, and when to apply this knowledge to answer questions and solve problems.

3.1.2.From focusing on process to focusing on outcomes

Initially, deep learning was just a kind of learning strategies that Marton and Säljö advertised for students to pursue understanding. Later, this kind of strategies were refined into the deep strategies to maximize meaning and deep motivations such as intrinsic interest in the learning process(Biggs, 1987). According to Biggs, deep strategies describe the way students are deeply involved in tasks. As a prerequisite, this kind of participation has gradually become an integral part of the deep learning process (Biggs, Kember, &Leung, 2001). In deep learning, deep participation represents the extent to which students are actively pursuing deep learning, and it refers to actively participating wholeheartedly. Today, with the emphasis on “student-centered” teaching, participation plays an increasingly important role in deep learning. Chinese scholar Yunhuo Cui (2017) even directly quoted cognitive participation to define deep learning: it is a learning that shows high involvement, high cognitive participation and gains meaning in a complex environment.

Although, after the 1970s, the demand for talents' ability has changed, that deep learning did not shift its attention from process to result until the Hewlett Foundation initiated the deep learning strategic plan in 2010. Different from the previous deep learning that focuses on the deep understanding and basic knowledge transfer, the later deep learning pays more attention to the acquisition and transfer of middle-level and high-level abilities. Correspondingly, deep learning is also known as a comparative name: deeper learning.

Through analysis of the situation at the time, the Hewlett Foundation proposed six deep learning abilities that need to be transferred and applied (The William and Flora Hewlett Foundation, 2012), they are mastering core academic content, think critically and solve complex problems, work collaboratively, communicate effectively, learn how to learn, and develop academic mindsets. Soon after, in order to explore the blend of transferable knowledge and skills and 21st century competencies, the US National Research Council identified three broad domains of competence—cognitive, intrapersonal, and interpersonal, and regarded these three competence domains as the three dimensions of deep learning knowledge and skills (National Research Council, 2012). In fact, the six deep learning abilities proposed by the Hewlett Foundation correspond to the three competence domains defined by the US National Research Council, and they both are also homogeneous with the capabilities of smart talents, as shown in Table 1.

Talble 1. The relationship between deep learning abilities, 21st century competencies and smart talents capabilities

competence domains	**six deep learning abilities proposed by the Hewlett Foundation**	**21st century competencies**	**smart talents capabilities**
cognitive	mastering core academic content	- key academic subjects -3Rs （i.e., Reading, wRiting, and aRithmetic	-master the basic knowledge proficiently
	think critically and solve complex problems (including the effective use of professional tools and techniques, as well as the ability to solve problems creatively)	- critical thinking and problem solving - computing and digital proficiency - creativity and innovation	- good at solving complex problems - good at judgment and creation
interpersonal	work collaboratively	- collaboration and leadership	- good at collaboration - make good use of technology
	communicate effectively (written, oral)	- communication and media literacy	-good at communication
intrapersonal	learn how to learn	- learning self-direction	-good at learning
	develop academic mindsets	- career, civic	- ingenuity, good personality, pragmatic

3.2. Complete solution of deep learning concepts

To sum up, the goal of deep learning has evolved from seeking understanding to pursuing transfer. It not only pays attention to the deep participation of students and the strategies students adopted in the learning process, but also pays attention to the mastery and transfer of higher-level skills. Therefore, this study summarized an elaborate definition of deep learning: Deep learning is a meaningful learning method based on understanding and pursuing transfer applications. It promotes the development of high-level knowledge and abilities by encouraging students to be deeply involved in learning and appropriate use of advanced learning strategies, then realizes the application of this knowledge and abilities in new situations or the generation of new high-level knowledge and abilities.

The definition suggests the following features of deep learning, a) deeply involved in learning, b) adopting advanced learning strategies, c) focusing on the development of high-level knowledge and abilities, and d) based on understanding and pursuing transfer are the four major characteristics of deep learning. Among them, deeply involved in learning means fully and actively participating. It focuses on student's learning involvement and the state of students' flow. Advanced learning strategy can be judged by "whether it is based on understanding" and "whether it pursues transfer application". Considering that deep learning should embody the idea of "student-centered", whether the learning strategy is advanced or not also needs to be judged "whether it reflects the initiative of the students".

High-level knowledge and abilities are as shown in Table 1. From the perspective of Bloom's taxonomy, it focuses on implementing (i.e., applying what learned in new situations), analyzing, evaluating, and creating. The understanding in d) is mostly in-depth understanding. Since reflection has been proven to be an important means of in-depth understanding (Haller, Fisher, &Gapp, 2007), this understanding can start with deep and repetitive thinking from multiple perspectives. Regarding transfer, considering that classroom teaching cannot cultivate all the knowledge and abilities to solve unknown problems in the future, this study also takes the combination or comprehensive innovation of existing knowledge and abilities as a kind of transfer. In this way, the transfer includes both the application of knowledge and abilities in new situations and the generation of new high-level knowledge.

4.The Bottleneck of Deep Learning Research

Based on our review and analysis, the existing deep learning research basically covered four major characteristics of the concept of deep learning. In addition, though the existing studies almost regard deep learning as a stable structure-oriented activity process, its flexibility issue has not received enough attention.

4.1.Deep learning demands flexibility

Whether to encourage students to be deeply involved in learning or to guide them to adopt advanced strategies, the ultimate goal of deep learning is to promote the development of students' high-order knowledge and ability and its transfer and application. Research has shown that only deep understanding can realize transfer applications, and reflection is an important means and

effective strategy to realize this understanding, what's more, some scholars even believe that reflection is the only mechanism for deep learning (Svensson, 1977). Reflection requires students to be able to review what they have learned, think repeatedly and revise existing ideas at any time. In addition, deep learning also needs students to be able to actively select suitable resources, tools, and carry out appropriate learning activities according to one's own needs. This personalization and initiative can help promote deep learning (Fullan, &Langworthy, 2014). Due to the uncertainty of the time for students to review what they have learned, the difference of review contents, and the unpredictability of their active choice of resource, tools and learning activities, the structure of deep learning activity progress should be diverse and flexible.

In the flexible progress structure, flexible and interactive self-inquiry guided by teachers is the key to the success of deep learning. Self-inquiry can make students believe that they have control over the content, methods, and time of learning, and can make them believe that their behavior is internally initiated. As a result, it leads to a greater preference for more challenging tasks and a greater willingness to put in more effort to understand (Grolnick, &Ryan, 1989), leading to deep learning. Research shows that cultivation and transfer applications of the high-level knowledge and abilities pursued by deep learning are very difficult for beginners, because they lack the schemas that experts use to solve new problems. This can easily lead to students' failure due to the lack of knowledge of self-inquiry without flexible interaction between students and teachers (Bransford, Brown, &Cocking, 2000). The failure case of deep learning of "learning while writing research papers" by Green et al. (2013) proves this point. The flexible interaction between students and teachers in self-inquiry are embodied in "individual needs, response whatever is requested, and fusion of request and its response", which is different from the teaching mode with clear distinction between student-led and teacher-led.

4.2.The challenge of flexibility

Flexibility is one of the six challenges of educational development and reform. Deep learning's demand for flexibility in the activity progress structure has touched on changes in the top-level framework structure, which further increases the difficulty of achieving flexibility.

In fact, the above flexibility is superficialn, what deep learning really needs is cognitive flexibility. This flexible feature is to organize teaching and teach knowledge in different ways, prompting students to repeatedly cross-learn (i.e., for the same content, repeated non-linear learning is carried out for many times from different perspective at different times and in different situations for different purposes). The process of repeatedly cross-learn is accompanied by the change of the context and the repetition of de-context and re-context. Context can bridge the world of knowledge and the world of life. In detail, de-context establishes a corridor from the world of life to the world of knowledge, prompting students to extract knowledge such as laws, trends, or common characteristics, and re-context establishes a corridor from the world of knowledge to the world of life: every time students solve a problem in a new situation, they will reassemble the extracted knowledge and construct the meaning of the current problem. In this way, students can form a rich and flexible understanding, and can flexibly apply or assemble relevant knowledge to solve problems in changing situations and realize transfer (Jacobson, 1996). This cognitive flexibility is a huge challenge in classroom teaching with limited time, heavy tasks and large

numbers of people.

5.Solution Measures

As to the above flexibility bottleneck, learning architecture may be an effective approach, because its outstanding feature is flexibility (MCEETYA, 2003), and it can help understand the depth of learning (Scanlan, 2013).

5.1.Towards a learning architecture

Shen (2017) provided the idea of transforming pedagogical structure into learning structure, considering the existing problems of education and combining the demands of smart learning. According to his view, learning structure advocates that students take charge of their own learning behavior, which is a unique organizational form about the presentation of learning content, organizational sequence, time allocation, self-detection and other elements formed by them with the support of specific learning space in order to achieve corresponding learning goals. In the learning structure, the main tasks of teachers are to analyze the changes of students' preferences and needs, to form diverse resources that meet their individual cognitive habits and their ways of representation and presentation, and to construct the support of various learning strategies. It is true that the learning structure fully reflects the individuality and initiative of students, and helps to promote deep learning (Fullan, &Langworthy, 2014), but it requires too high a student's learning ability and is not suitable for the basic education of primary and secondary schools. More importantly, the unique form of learning organization it represents is still concerned with the stability of teaching and learning. Therefore, this study believes that teaching needs to move towards a learning architecture, so that teaching can not only focus on the individuality and initiative of students' learning like a learning structure, but also cater to the demands of deep learning: flexibility. The relationship among pedagogical structure, learning structure, and learning architecture are shown in Figure 3.

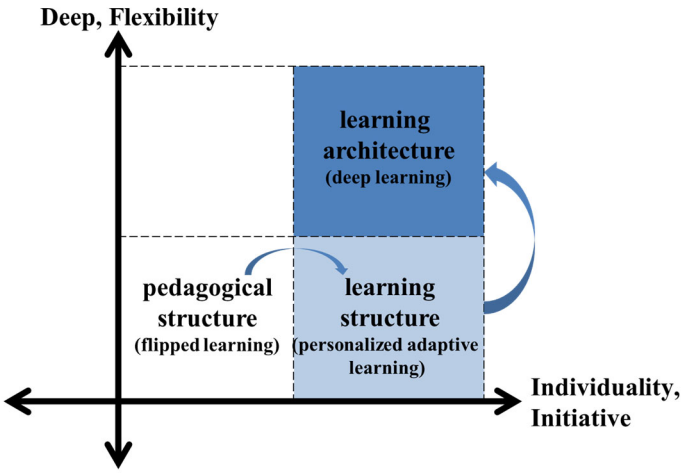

Figure 3 The relationship among teaching structure, learning structure and learning architecture

5.2. Smart classroom empowerment

Fundamentally, the shift to flexibility is driven by the development of technology. In theory, a smart classroom that integrates a variety of advanced IT technologies and media devices can empower the flexibility of deep learning. So far, although, it has not made deep learning happen as we expected.

As a paradigm of smart learning environment, smart classroom has all the functional characteristics of smart environment: seamless connection of learning space, keen perception of learning context, natural interaction of learning experience, precise adaptation of learning services, full recording of the learning process, and open and integrate of data resources (Zhu, Yu, &Riezebos, 2016). These functional characteristics give students more flexibility, effectiveness, adaptability, participation, motivation and feedback (Spector, 2014), and empower teachers and students to flexibly carry out in-depth teaching and learning. These functional characteristics give students more flexibility, effectiveness, efficiency, engagement, adaptivity,and reflectiveness (Spector, 2014), and empower teachers and students to flexibly carry out in-depth teaching and learning. Specifically, smart classrooms can flexibly create or connect context or real situations, and realize the arbitrary change of context required for cognitive flexibility;It can adaptively respond to the learning needs of students, and provide the appropriate learning support, personalized help and rich media-like learning resource ecology required for repeatedly cross-learning. Among them, the recommendation of personalized generative paths will lead to the diversity of the activity progress structure. This flexible progress can be fed back to teachers and students in real-time in a visual form.

In addition, smart classroom can pay attention to the learning status of each student, make teachers more capable of supervising, guiding and evaluating students, and feel more confident to give more initiative to students. This can also stimulate students' interest, motivation and creativity to achieve efficient and productive learning and achieve the goal of deep learning outcomes (Li, Kong, &Chen, 2015). Yu and Chen (2018) pointed out that smart classroom is a new type of classroom form that seamlessly supports deep learning with technology. However, the above research status diagram shows that the empowering role of the smart classroom has not been well explored: the smart classroom does not appear in Figure 2, and the smart learning environment as the upper concept of the smart classroom is only on the edge of extreme remoteness.

6.Conclusion

The analysis of this study shows that after more than 40 years of development, the research of deep learning has gone through dormant period, germination period, emerging period, and is now in the rapid development stage. At present, the research trend of deep learning is to promote students to be deeply involved in learning and the appropriate use of advanced learning strategies.

Two major changes of deep learning occurred in the past 40 years: a)from pursuing understanding to pursuing transfer, and b) from focusing on process to focusing on outcomes. Morover, deep learning is no longer just a learning approach to understand basic knowledge, it is more of a meaningful learning method based on understanding and pursuing transfer applications. It promotes the development of high-level knowledge and abilities by encouraging students to be

deeply involved in learning and appropriate use of advanced learning strategies, then realizes the application of this knowledge and abilities in new situations or the generation of new high-level knowledge and abilities. Among them, the generation of new higher-order knowledge and abilities is a new aspect of transfer that we advocate.

However, the analysis revealed that the flexibility of deep learning is currently overlooked, while flexibility is the appeal of deep learning. This appeal involves the change of the top-level framework structure and requires cognitive flexibility which might be extremely challenging to achieve. In this regard, this study suggests that deep learning move towards a flexible architecture and try to solve this problem with the help of the enabling of a smart classroom.

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Teacher Made Videos: A Comparative Analysis of Two Approaches to the Creation and Use of Self-made Teacher Videos in the Secondary Classroom

Joseph R. Riddle

Special Programs Coordinator, Lone Oak Middle School

Abstract

The challenges of the 2020 global COVID-19 pandemic have thrust K-12 teachers into the world of online and hybrid learning. As a result, many teachers are looking for new and innovative ways to provide learning opportunities to students through online videos. The popular social media video streaming site YouTube provides a convenient resource for teachers to share video content as well as for researchers to observe teaching. This study provides an exploratory analysis of two differing approaches to creating and using teacher self-made videos in secondary classrooms. The study compares videos that were filmed in class, which document specific problem solving, with those made out of class to deliver direct instruction. Descriptive statistics provide insight into key comparisons of video length, number of views, and identify areas of interest; Distractions, Advertisements, Technology Troubles, Video Issus, and Audio Issues that were all found to influence delivery of instruction through online videos.

Key Words: Teacher Self-made Videos, K-12 Teacher Videos, YouTube, Secondary Education, Online Learning

Introduction

The COVID-19 pandemic has catapulted learning technology into the forefront of education (Bonafini & Lee, 2021; Fackler & Sexton, 2020; Smith & Colton, 2020). Teachers have been compelled through circumstances to adopt technology-based learning approaches that many were reluctant to accept and implement prior to the pandemic (Francom et al., 2021). Teachers are quickly moving to create rich learning opportunities to address the needs of their students and provide support to parents as at-home learning facilitators (Archambault & Borup, 2020). This includes the use of videos in both synchronous and asynchronous settings. Lowenthal and Covey (2021) observe that video is an effective instructional tool that is also well suited for conducting education research. The purpose of this study is to provide an objective review of these teacher-made videos to better understand the varied approaches to both creating videos and how they are used to deliver or support instruction in the K-12 secondary classroom.

Literature Review

Anecdotal observations of instructional videos used in the classroom prior to the pandemic were primarily limited to those produced for educational use by outside organizations. Videos used in the classroom were selected based on their relevance to the topic being taught and sometimes lessons were formed to fit around the video. As more teachers move to online and

hybrid models of learning, it has become more difficult to utilize existing videos to meet the needs of all students. Innovative teachers have turned to creating their own instructional videos to deliver content to their students, which may be attributable to the extensive use of video in teacher preparation programs (Hollingsworth & Clarke, 2017). Lowenthal and Carvey (2021) observed that "despite the increased use of video in teacher education, questions remain about effective ways to use video in online video-based instructional modules" (p.225).

The Challenge of Rapid Transition

The sudden shutdown of schools and the government imposed at-home quarantines which necessitated the abrupt jump to distance learning revealed how unprepared many educators are to provide technology-based learning (An et al., 2021; Francom et al., 2021; Hodges et al., 2020). Despite the prevalence of technology in society and the classroom, many teachers and administrators continue to rely upon traditional models of instruction that are dependent upon location and presence (Smith & Colton, 2020). While online learning can offer many affordances, the transition from theory to practice can present unique challenges in normal times and even more so during a global pandemic (Hodges et al., 2020; Johnson et al., 2019; Tawfik, 2021). An et al. (2021) observed that "many schools and teachers were not well prepared for the sudden move to online teaching due to the pandemic" (para. 2). Using videos can help teachers draw students into the learning environment regardless of their physical location to facilitate learning (Di Paolo et al., 2020).

The use of videos in the K-12 classroom has been a common practice for decades (Aranya, 2020). Today more teachers are leaving textbooks behind in favor of digital resources that include high quality videos (Blomgren, 2018). Indeed, many teacher education programs now actively incorporate the use of videos in a variety of ways to prepare teachers for the classroom (De Voto & Thomas, 2020). The shutdown of schools due to the COVID-19 pandemic can be seen as "an unprecedented crisis and differs from other major school emergencies, such as school shootings and bomb threats" (An et al., 2021, para. 2). Hodges et al. (2020) noted that "well-planned online learning experiences are meaningfully different from courses offered online in response to a crisis or disaster" (para. 1).

YouTube: Working in a Familiar Space

YouTube is a global social media website where users share original videos. According to the YouTube website, "millions of people come to YouTube to be informed, inspired, or just plain delighted" (YouTube, n.d.). While YouTube is a popular media platform, Di Paolo et al. (2020) state that "technology alone does not motivate students to learn; however, instructors can use technology purposefully, effectively and efficiently to enhance learning (p.452). Lowenthal and Covey (2021) also identify video as a powerful media format that "can show things in ways that previously were not possible" (p.233). Teaching under what are considered normal conditions can be a complex process (Cuenca & Zaker, 2019). Because of the social restrictions created by the COVID-19 pandemic, both parents and education leaders have increased their demands on teachers to provide and promote effective technology-based learning opportunities

(Bonafini & Lee, 2021). Fackler and Sexton (2020) observe that the current climate creates a "complex nature of teaching in these uncertain times" (p. 11).

Lingering Questions Remain

Questions remain around what constitutes a good video and why teachers choose to use existing videos or make their own videos for their classrooms (Wijnker et al., 2019). More information is needed to help educators understand "details on how video is recorded and selected when developing video-based instructional interventions" (Lowenthal & Cavey, 2021, p.226). Di Paolo et al. (2020) identified four significant areas of consideration as "planning, development, delivery and reflection" in the meaningful use of online videos for distance education (p.459). Circumstances for learning and educational technology are continually changing and evolving, therefore repeated evaluation of ongoing efforts are needed to ensure that students continue to receive the education they both need and deserve.

Methodology

Purpose and Participants

The purpose of this study is to add to the understanding of how teachers are using self-made videos to teach students as a result of the COVID-19 pandemic's influence on education. Specifically, the study compares publicly available videos on YouTube from two secondary teachers with differing approaches to classroom video creation and use. This study utilizes a nonrandom, purposive sample of teacher self-made videos from two teachers who demonstrate differing approaches to creating and using video-based instruction in the classroom. Both teachers began posting videos regularly on YouTube in August 2020. This study reviews videos posted over the fall semester from August 2020 through December 2020.

Teacher 1 is a secondary math teacher from a rural school district with approximately 2,000 students. Teacher 1's primary approach to creating videos is through in-class recordings that are uploaded for students to review after class or at home asynchronously. Teacher 1's first YouTube video was a virtual open house that posted August 19, 2019 and was not part of the study. The next video posted by Teacher 1 was on August 19, 2020, when Teacher 1 began posting videos regularly that corresponded with work done in the classroom.

Teacher 2 is a secondary biology teacher in a district of approximately 5,000 students. Teacher 2's primary approach to creating videos is through prerecorded lectures that are uploaded for students to view before, during, and after class, or asynchronously for at-home students. Teacher 2's first YouTube video posted on September 14, 2020, followed by subsequent videos that were reviewed as part to the study.

Materials, Data Collection, and Procedures

This study utilized commercially available internet enabled computers with internet browsers to view online YouTube videos. Data was collected from both teachers on videos that were posted between August 2020 and December 2020. Videos were selected from each teachers YouTube channel by selecting the videos tab and then sorting the videos from oldest to newest.

Videos were watched in the order they were posted. Each video that was posted during the time frame of the study was selected and viewed from start to finish. The video play back speed for most videos was set between 1.5 to 2.0 to facilitate efficient review. Where clarification was needed, the video speed was adjusted to normal. Collected data was stored in a spread sheet and backed up on a portable storage drive. Built in formulas within the spreadsheet software were used to calculate descriptive statistics.

Results

Over the course of the study, both teachers posted videos regularly on YouTube. Teacher 1 posted more frequently, with 152 total videos, than Teacher 2, with 32 total videos. The total length of combined videos for Teacher 1 was 20 hours and 9 minutes. While Teacher 2 recorded and posted a total of 7 hours and 47 minutes. The average video length for Teacher 1 was 7.95 minutes and for teacher two it was 14.49 minutes (see Table 1).

Table 1

	Total Videos	Total Time of Videos	Average Video Length
Teacher 1	152	20 hours 9 minutes	7.95 minutes
Teacher 2	32	7 hours 47 minutes	14.49 minutes

The key difference to the creation of videos between Teacher 1 and Teacher 2 was whether the videos were made in class or out of class. In class videos are videos made with students present, and out of class videos are videos made without students present. Teacher 1 made 82.24% of videos in class and 17.76% of videos out of class. Teacher 2 made 6.25% of videos in class and 93.75% of videos out of class (see Table 2). There were also significant differences between the number of views each teacher received for their videos. Table 2 shows that Teacher 1 received 1,336 total views for an average of 8.78 per video while Teacher 2 received 5,719 total views for an average of 178.71 views per video.

Table 2

	In Class	Out of Class	Total View	Average Views
Teacher 1	82.24%	17.76%	1336	8.78
Teacher 2	6.25%	93.75%	5719	178.71

During the viewing of videos several important areas of interest emerged, specifically Distractions, Advertisements, Technology Troubles, Video Issus, and Audio Issues. Distractions were identified as anything that took away from the lesson or teaching being presented. Advertisements were separate from the video content and part of the YouTube streaming platform. Technology Troubles were any issues associated with technology devices not working correctly on camera. Video Issues were typically glitches in recording that could not be attributed to user error. Similarly, Audio issues were issues with audio feed that could not be attributed to user error. Table 3 shows the percentage of videos for each teacher according to these categories.

Table 3

	Distractions	Advertisements	Technology Troubles	Video Issues	Audio Issues
Teacher 1	26.32%	0.00%	37.50%	31.58%	36.84%
Teacher 2	21.88%	46.88%	3.13%	31.25%	31.25%

Discussion

An initial overview of the data collected for both teacher's reveals a large difference between the total number of videos posted by each. Teacher 1 posted nearly five times more videos than Teacher 2. This is explained through data collected from the videos and provides insight into why each teacher may have chosen their particular approach to creating videos. Teacher 1 created and posted videos for at least two classes and possibly a third. Because the videos were posted to YouTube and then linked to assignments in Google Classroom, it is not readily clear which videos went with which classes however, it is clear that Teacher 1 created videos for a Fundamentals of Math and a Geometry class. Teacher 2 created videos for a high school biology class, and as observed in the videos often recorded during the teacher conference period. Having one lesson to prepare is quite different than having two lessons to prepare which may explain why Teacher 2 chose to create videos prior to class and Teacher 1 out of necessity and a lack of time created videos in class. This may also help to explain why Teacher 1's videos were on average only about half as long as Teacher 2's videos. Whereas Teacher 1 focused on delivering direct examples of how to work problems, Teacher 2 used the video for direct instruction.

Considering the circumstances of each teacher also helps to explain the percentages of videos that were made in class vs out of class. Noticeably, Teacher 1's out of class videos were made while the teacher self-reported to be under personal quarantine or while the school was physically closed, and students participated in at-home remote learning. No clear explanation emerges for why Teacher 2 chose to create some videos in class with students present, though it should be noted that some of the out of class videos were made from home while the school was also closed, and students were switched to remote learning. Notably both schools, from different school districts, experienced physical closures and forced distance learning due to the COVID-19 pandemic during the study period.

When looking at the average number of views per video there is a dramatic difference between Teacher 1 and Teacher 2. Teacher 2 had nearly twenty times more average views than Teacher 1. This perhaps due to the way the videos were used in class, however without access to specific viewer data it cannot be clearly stated why Teacher 2 had so many more average views than Teacher 1. However, it is reasonable to conclude that their approaches to using the videos contributed to more views for Teacher 2. Teacher 2 used the videos as lectures for students, and also included comments to non-students, which may be partly why the general nature of the informational videos may have attracted a larger audience. Teacher 1, who used the videos to document working specific problems in class may have received fewer views because of the specific nature of the content as well as the redundancy for students that had already seen the problems worked in class.

The information gathered in Table 3 provides perhaps the greatest insight into a comparison of the two approaches to classroom video creation. Distractions ranged from classroom announcements during both teacher videos, to off task students, and the teacher engaging in sidebar conversations. Noticeably, the percentage of videos with distractions was closely similar with both teachers. Teacher 1 had no advertisements before, after, or during the posted videos so it came as somewhat of a surprise when almost half of Teacher 2's videos had at least one and often multiple advertisements associated with them. Further review revealed that Teacher 1's account was marked by YouTube as child related so comments were disabled and a link for YouTube kids was at the bottom of the page. Teacher 2's account was not marked for children, so the content was not limited. The presence of advertisements on required videos creates ethical questions and an opportunity for further research and discussion. Technology troubles were observed as both teachers struggled with their own issues. The increased number of Technology Troubles experienced by Teacher 1 is partially attributed to the fact that the videos were created during live class sessions and presented little opportunity for error. A simple glitch for Teacher 1 affected both the recordings and the real-time student instruction. Recording outside of class time may explain why Teacher 2 had significantly fewer Technology Troubles. Quality of the recording equipment became a factor for both teachers, as both experienced a similar percentage of issues. Video issues for Teacher 1 were related to incorrect orientation, failure to stop and start when intended, and video skips that created gaps in instruction. Video Issues for Teacher 2 were related to the quality of the camera and the lighting. Teacher 2 often lectured in front of a smartboard that created back lighting and shadows as well as issues of keeping the content on the smartboard in frame and clearly visible to students. Audio Issues for Teacher 1 were related to the difficulty of recording all of the audio in a classroom with a single microphone. Videos posted by Teacher 1 were filled with one sided conversations because most of the student's comments and questions could not be understood. This finding seems to support Ferdig and Kosko (2020) observation that the physical proximity to the camera can provide an advantage to those who are closer and a disadvantage to those who are further away. Audio Issues for Teacher 2 were attributed to movement by the teacher while lecturing as the audio would fade in and out as the teacher faced the board and then turned to face the camera.

Considerations for the Future and Conclusions

Understanding how these videos are created and used in a way that is both efficient for the teacher and effective for the student is critical. Additional research has concluded that teacher made videos may offer help in "understanding the complexity of classroom teaching but also builds spaces for reflective thinking and learning through practice" (Wetzel et al., 2017, p.535). As required changes begin to ease, it will fall more to education leaders to set a tone for the continued use of tools deemed essential during the pandemic (De Voto & Thomas, 2020). Farmer and West (2019) conclude that "as new online programs emerge and existing programs continue to develop, policies and practices at an organizational level should be established only after careful consideration of their impact on teachers" (p.116). The COVID-19 pandemic has forced the rapid creation of technology-based learning content. Helping teachers understand the pros and cons of various approaches to media creation will help them make more informed decisions about how to best serve their students. "Teacher educators must find real-world

opportunities to develop technology-based instructional experiences for teachers to develop technology competencies" (Smith & Colton, 2020, p.454).

This study has sought to provide both current and future teachers with a better understanding of issues associated with two approaches to creating videos for classroom use. Teachers who create videos for classroom use must decide when and how they will create the video and how the video will be used to support learning. The shutdown and subsequent measured reopening of schools has forced teachers to consider new ways of educating students. As more teachers turn to creating their own video content consideration is naturally given to how these videos will be made and what purpose the videos will serve in the classroom. Lowenthal and Cavey (2021) observed that "as it becomes easier and easier to create, edit, and share video, educators, instructional designers and curriculum developers, and researchers will continue to experiment with ways to intentionally use video to improve teaching and learning" (p.233). Recording videos in a live classroom setting provides relevant examples for students to draw upon as they recall the experience. However live classroom recordings are also subject to disturbances and distractions that teachers may not have time to edit out. Recordings that are made ahead of time offer teachers a more thought-out opportunity to deliver direct teaching, yet it can be time consuming to prepare, create, and then post a video. Videos made prior to class however do offer greater flexibility when considering how they will be used. Teacher made videos offer more specific instruction to students from a relevant and reliable resource. One question that remains is whether technology practices that were implemented due to the extreme circumstances of the global pandemic will continue as part of the new normal or fade away into old habits (Tawfik, 2021).

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More Questions and Answers for the Flipped Classroom Approach: A Review of Reviews

Feng-Ru Sheu,
Kent State University, fsheu@kent.edu

Mei-Lun Shih,
National Taiwan University, mshih@ntu.edu.tw

Abstract

In recent years, the educational strategy called the flipped classroom (FC) has gained notable publicity and popularity in education. A substantial number of articles related to FC have been published aimed to synthesizing this extensive body of research on the flipped classroom. Hereto, this paper examined 13 reviews aiming to identify the characteristics of review studies and the current state of knowledge on the flipped classroom as a pedagogy approach. Despite the methodological differences, the results of this review confirm that FC has positive impacts on students' learning experiences in general. This study revealed a need for increased support for research in FC design, implementations, and practices. More longitudinal analyses are necessary to better understand the best practices of FC implementation or whether the effectiveness of FC practices is influenced by contextual elements, such as disciplines, subject domains, the complexity of learning content, academic levels, and implementation duration.

Keywords: flipped classroom, inverted classroom, scope review, comparison study

Introduction

Flipped classroom (FC) is an instructional approach that extends traditional classroom-based learning through technology (Karabulut-Ilgu et al., 2018). FC is also referred to as inverted learning or flipped learning. The concept of FC emerged in 2000 when Lage, Platt, and Treglia proposed the idea of an "inverted classroom". In an inverted classroom, the students' first learning activity happens before the class and then uses the in-class time for more engaging activities like problem-solving (Lage et al., 2000). In 2007, FC gained its popularity after two high school teachers, Jonathan Bergmann and Aaron Sams, used video lectures as students' pre-class assignments for their chemistry classes (Lage et al., 2000; Tucker, 2012). Various models were proposed for FC implementation, such as the FLIP model (i.e., flexible environment, learning culture, intentional content, and professional educator) (Flipped Learning Network, 2014) and "FLIPPED" model, which extends the FLIP model by adding three more elements (i.e., progressive activities, engaging experiences, and diversified platforms (Chen et al., 2014). While there is no fixed model, the essential idea of FC is to have lectures and direct instruction delivered before class through online videos. And then, the actual class time is used for more engaging collaborative learning activities, such as hands-on activities, discussions, and interactions (Flipped Learning Network, 2014; Tucker, 2012). The instructional approach aims to

transform students from passive learners to active learners, who can self-direct their learning to improve personal analytical, integration, and critical thinking skills for higher levels of learning (Hu et al., 2017).

Given the advancement of technology that provides tools for delivering flipped learning, FC has gained much popularity and scholarly attention in recent years (Akcayir & Akcayir, 2018; Bergmann & Sams, 2012). Various class activities, teaching tools, and techniques have been used to carry out the FC approach (Lundin et al., 2018; O'Flaherty & Phillips, 2015; Ward et al., 2018). Examples of the inside- Fand outside-of-class activities include reviewing case studies, playing games, role-playing, working on peer-reviewed assignments, watching video-recorded lectures, and working on post-class homework (Ward et al., 2018). The teaching techniques used in FC include prerecorded lectures, case-based presentations, team-based discussions, panel discussions, and debates (O'Flaherty & Phillips, 2015). Digital technology is also used to implement FC. For example, social media or networking sites like YouTube or blog posting is applied as platforms to share educational resources (Lundin et al., 2018). Additionally, the FC approach is widely implemented across different education levels, such as K-12 and higher education (Cheng et al., 2019), and disciplines, like engineering (Kerr, 2015), clinical pharmacy (See & Conry, 2014), chemistry (Baepler et al., 2014), and computer science (Giannakos et al., 2014).

The advantages of FC included better students' learning achievements, improvement on learning experiences, and increases students' motivation and satisfaction during the learning process are broadly indicated in previous research (Koo et al., 2016; Sergis et al., 2018). On the other hand, the challenges of FC included time limitation for pre-class activity preparation, time-consuming and less effective for learning (Koo et al., 2016; Roehling et al., 2017).

For a field to continuously progress, it is essential to be aware of its developmental patterns in the past to obtain insights for future implications (Dwivedi et al., 2011). As FC has progressively expanded over the years, a lot of research addressed the development of FC and its impacts. However, each review has its own focus, scopes, and comprehensiveness (Karabulut-Ilgu et al., 2018; Oliver & Luther, 2020). For instance, Cheng et al. (2019) reviewed the impacts of FC on students' learning outcomes. Liu and colleagues' (2019) review focused on the teaching effects of FC. Some research addressed FC and its impacts on both teaching and learning (Karabulut-Ilgu et al., 2018; Oliver & Luther, 2020).

Furthermore, mixed results were reported in the review studies with a focus on FC effectiveness. Researchers indicated that the positive impacts of FC on student learning, which included better learning performance, enhanced student engagement, increased student satisfaction, the development of problem-solving and cooperation skills, and improvement of theoretical knowledge (Akcayir & Akcayir, 2018; Hu et al., 2018; Karabulut-Lieu et al., 2018). On the other hand, although research results showed that FC in class seemed to produce positive learning outcomes, the effect is not long-lasting and not all course evaluations are positive (Betihavas et al., 2016; Presti, 2016).

With the different perspectives of examination of each review, different sets of studies might be selected, and, accordingly, different analysis results and conclusions would generate. Despite the contribution of these researchers, the diversity in selected information in existing review articles prompts a need to conduct a review of reviews study to provide a synopsis of the evidence of FC. Reviews of reviews are referred to as umbrella reviews, reviews of systematic reviews, overviews of reviews, a synthesis of reviews, and a summary of systematic reviews

(The Joanna Briggs Institute, 2014). This approach has been used to summarize the extensive scientific knowledge on widely explored research topics in nursing and medical fields (Egan et al., 2008; Mikton, & Butchart, 2009) and is becoming increasingly common in education and other fields (Chen et al., 2018; Pahlevan-Sharif et al., 2019). Reviews of reviews aim to summarize the existing research syntheses regarding a topic of interest (The Joanna Briggs Institute, 2014), which is compatible with the purpose of this current study.

The purpose of this study is to provide an overview of the features and impacts of FC from previously published FC reviews in the past decade. Through the lens of reviews of reviews, the close investigation of relevant FC reviews can provide vital insights into the expanding and popular trend of FC and to identify the insights to shed light for future research. This study is intended to capture the essence of the existing reviews in the area of FC to answer the following research questions:

1. What are the characteristics of review studies on the flipped classroom?
2. What are the findings of the FC reviews?

Methodology

Standard reviewing methods were applied in the current study to identify existing reviews, instead of primary research (Khan et al., 2001). The present study uses reviews as the unit of analysis, which differs from a conventional review that uses primary studies as the unit of analysis (Kache & Seuring 2014; Keller & Torre, 2015).

Search Strategy

Social Science Citation Index (SSCI) was the database used to identify the relevant reviews on flipped classrooms. SSCI was selected because it covers top-tier or highly ranked journals in social sciences based on the sophisticated selection process, specifically, the Web of Science Core Collection Journal Selection Process (Web of Science Group, 2019). The Web of Science (WoS) platform, one of the largest academic database search platforms, was applied to access SSCI.

In order to identify the largest possible number of articles in our initial search, the authors of this study used strategies that included a range of terms for their main research variables (e.g. flipped classroom, flipped approach, flipped instruction, flipped learning strategies, inverted classroom, systematic review, meta-analysis, scoping review, etc.). The Boolean operator “or” was used with related terms to broaden their search before narrowing down by the selection criteria. They also used truncation to include variation of words. For example, the authors used “flip*” to find items, including terms like “flip,” “flipping,” and “flipped” and “invert*” to search article items that contained “inverting” or “inverted.” After completing the above search process, they further applied selection criteria to screen out irrelevant results. The language restriction was English.

Inclusion and exclusion criteria

Criteria for inclusion of papers included (a) peer-reviewed journal articles; (b) articles classified as reviews, systematic reviews, or meta-analyses; (c) articles that reported on/about the flipped classroom; and (d) articles that were published in English. Studies were included if they reviewed any studies on the flipped classroom. Studies that did not meet these inclusion criteria were excluded, such as those that reviewed conference papers instead of published journal articles, studies that did not follow the systematic analysis procedure, and those that failed to report the process of literature selection. Restricting eligibility to publications in peer-reviewed journals enabled consistent quality across disciplines and databases covered in the literature search.

Selection process and data analysis

After completing the initial search process, all studies were examined by the two authors. After the initial database search, the two authors independently scrutinized the titles and abstracts from the electronic searches followed by the full text of all citations that definitely or possibly met the predefined selection criteria. If a disagreement occurred between the two authors, a third person would share their judgment. A discussion would follow among the three individuals until a consensus was reached. This exact process was also applied when a disagreement occurred during the coding stage.

After excluding duplicated records identified across SSCI searches, the titles and abstracts of 361 records were screened. After a full text review and discussion, a total of 13 unique reviews met the inclusion criteria. The two authors assessed the manuscripts independently and resolved any disagreements about inclusion by consensus after discussion. For each study included, information was obtained, such as bibliographical data, study purpose, study design, learning context, and primary results. Content analysis is the approach for data analysis. Both authors coded the qualitative data attained from the articles, respectively. Any discrepancies in the coded data between the two authors were discussed with a third reviewer until reaching a consensus of the coded data.

Results

Characteristics of the Included FC reviews

This section discusses the characteristics of retained FC reviewed, including background information (i.e., publication year, academic discipline, education level), research focus, and research methods.

Background information. Results show that one to two FC review research were published in 2015, 2016, 2017, and 2019. However, in 2018, the FC reviews publications peaked when seven articles were published that year. Additionally, authors of the 13 FC reviews came from a variety of regions, including North America (five articles from the U.S.), Asia (two from Hong Kong, one from China, and one from Taiwan), Europe (one article from Turkey and one article from Sweden) and Australia (two articles). All of the FC reviews focused on English-

based FC studies. Nine of the 13 FC reviews examined FC studies within a single academic discipline, including nursing (4), health (2), engineering (1), mathematics (1), and education technology (1). Moreover, the majority of them examined the effectiveness of FC in the context of higher education.

Research focus. When examining the purpose study of the included FC reviews, four different research focuses emerged, including overall trends, effectiveness of FC on learning, current state of FC knowledge or practice, and benefits and challenges of FC implementation. It is worth noting that some of the included FC reviews may have had more than one study focus and/or was conducted in multiple stages. For example, the review of Lo et al. (2017) initially conducted a meta-analysis of 21 comparison studies about FC to examine the effects of FC for math education learning, following synthesized findings of 61 FC studies to identify the benefits and challenges of FC on students' learning.

Some features were found among the FC reviews with the same research focus. For example, the FC reviews that focused on FC current development situation frequently applied some aspects to present the developmental trend among the FC studies, such as publication trend (i.e., year, author, publication venue), keyword, and subject area. The FC reviews that focused on FC effectiveness examined the issues and factors related to the effect of FC approaches on teaching and learning, such as students' academic levels and duration of implementation. Furthermore, some of the FC reviews that addressed the current knowledge or practice status of FC also investigated the development or effectiveness of FC. For example, Ward's (2018) review integrated the application of FC in nursing education based on 14 related literatures. In addition to identifying main FC application themes in nursing education, students' academic learning outcomes and their measurements were also provided.

Research methods. Research methods of FC reviews can generally be categorized into qualitative and quantitative. The qualitative methods focused on content analysis to generate common themes among studies, and the quantitative methods studies focused on numerical data. However, some qualitative studies may have used quantitative data-analysis techniques, such as frequency or percentage analysis to describe the themes. Therefore, the authors broadly sorted FC reviews into three categories of research methods: qualitative review, quantitative review, and mix-method review. Among the thirteen FC reviews, one of them used a mixed method (8%), seven used a qualitative method (54%), and five of them used quantitative methods (38%) to analyze data. In terms of research approaches, there were meta-analyses, systematic review, literature reviews, and scoping review. All qualitative reviews utilized content analysis. Furthermore, FC reviews indicated that techniques and standard content analysis were used for qualitative data analysis, such as the coding protocol, rating scale, and framework. Some included studies that applied more than one research approach. For example, the study of Lo et al. (2017) stated that they applied two approaches, such as content analysis and meta-analysis. The content analysis was used to examine current FC practice, and the meta-analysis method was used to conduct the statistical data of the effect value by homogeneity studies.

Primary Findings of FC Reviews

Three overarching themes emerged from results of FC reviews, including overall trends, effectiveness of FC on learning, and benefits and challenges of FC implementation.

Research trends of FC studies. The top two main trends of FC studies in this FC reviews were (a) focused more on higher education and (b) small-scale research. Higher education was the development trend that was indicated most frequently in eight of the thirteen included FC reviews. For example, Akcayir and Akcayir (2018) pointed out a particular composition of FC studies participants. While the FC approach seemed suitable for courses in all learning levels, many study participants in existing FC studies are composed of students in higher education institutions. Moreover, Cheng et al. (2019) pointed out that accessibility of study participants is also one of the reasons for this, since FC researchers are mainly from higher education institutions. It might be easier for them to find access to student populations in higher education than in K-12 schools.

Small-scale research was also frequently used by FC studies, as it was indicated in half of the included FC reviews. Although the length of time of FC implementation varied considerably study-by-study, seven of the thirteen reviews revealed that many of the FC studies were small-scale research, such as small sample size, localized recruitment, and descriptive design. The duration of the implementation mostly ranged from one unit in a semester to one full semester. The tendency of localization in FC studies might result in the application of small-scale design. For example, 26 of the 31 FC articles that Lundin and colleagues (2018) reviewed were composed of experiences from a single course or classroom.

Effectiveness of FC on learning. Results showed that both qualitative and quantitative analysis methods were used to examine effectiveness of FC on learning. Table 1 summarizes the study findings regarding the effectiveness of FC that is indicated in the included FC reviews. To summarize, 12 of the 13 FC reviews concluded that FC had overall positive impacts on learning compared to in-class, lecture-based learning. It is also worth noting that Chen et al. (2018) found a progressive improvement tendency in the FC outcomes over time through a meta-regression analysis. In other words, FC studies published in recent years seemed to support the improved outcomes under FC conditions more. Moreover, the effectiveness of FC was usually evaluated through academic performance (n=4), satisfaction (n=5), engagement (n=4), motivation (n=1), and self-reported learning attitude (n=1).

Table 1
Summary of Findings Regarding the Effectiveness of FC

Category	n	Source of Review
Overall positive impact on student learning outcomes	12	S1, S2, S3, S4, S6, S7, S8, S9, S10, S11, S12, S13
Academic performance (e.g. test scores, course grade, knowledge score)	4	S2, S3, S4, S8
Satisfaction	5	S3, S9, S10, S11, S12
Engagement	4	S3, S6, S9, S11
Motivation	1	S3
Attitude	1	S3
Factors on the effectiveness of FC		
Type of content knowledge	5	S1, S8, S11, S12, S13

Subject areas/discipline	3	S1, S4, S13
Student levels (K-12, HE)	2	S1, S3
Duration of Implementation	2	S1, S3,

Some FC reviews further examined influential factors associated with the differences in the positive effects of FC on learning and found possible factors, including content knowledge (n=5), subject area (n=3), student academic level (n=2), and duration of implementation (n=2). In terms of knowledge content, many FC reviews concluded that FC had greater impacts on improving practical knowledge learning, such as design and experiment than theoretical knowledge learning (Hu et al., 2018).

Results also indicated that the variance of FC effectiveness in learning was within different subject areas. For example, Cheng et al. (2019) found a higher effect size of FC on learning subjects like art and humanities than social sciences, mathematics, health, etc. Chen et al. (2018) indicated that the FC approach had greater positive application impacts on medicine and pharmacy than nursing and other health-related professions. The difference may be reasonable, since the FC approach did not seem applicable to certain types of content knowledge. Therefore, it was necessary to consider the subject area's features when the FC approach was applied. Additionally, the effects of FC on learning outcomes among different student's academic levels were not conclusive. Akcayir and Akcayir (2018) indicated that the effects of FC on learning outcomes were higher in older learners. However, Cheng et al. (2019) found that the impact of FC approach outperformed the non-FC approach in higher education, but the effects on graduate students were overall negative. This means that postgraduate students learned better in non-FC conditions. The duration of FC implementation may result in differences in the FC effects, and a shorter implementation period seemed better. Cheng et al. (2019) found that overall, while students in FC were significantly outperformed students in non-FC conditions, the FC studies with a longer duration of FC implementation had smaller effect sizes than studies with a shorter period. Akcayir and Akcayir's (2018) study also indicated a similar conclusion that the effects of FC might not sustain over longer-term applications.

Benefits and challenges of FC implementation. The benefits of FC implementation commonly reported by both students and instructors were flexibility, it enabled individualized learning, and students were better prepared before class (Akcayir & Akcayir, 2018; Karabulut-Lieu et al., 2018). In addition to the benefits of FC implementation, challenges of FC implementation were noted in the FC reviews. For instance, there were concerns about the quality of the learning materials, the time-consuming nature of FC for course content preparation, technological issues, the need for out-of-class activity guidance, and the time required by instructors to integrate into their curriculum. Some FC reviews also indicated possible conditions that hindered instructors from adopting the FC approach. This was especially true regarding courses that involved large amounts of factual content and hand-on activities as well as the requirement of frequent interactions and collaborative group activities (Akcayir & Akcayir, 2018; Karabulut-Lieu et al., 2018; Lo et al., 2017).

Discussion & Conclusion

This review of reviews included 13 studies about FC that were published by SSCI-indexed journals in the last decade. The results of FC reviews raised some concerns about the existing FC studies from the following aspects, including the study design of FC studies, the definition of learning effects, and the analysis of FC effectiveness.

The Study Design of FC Needs to Be More Diverse

Regarding the study design in investigating FC practices and evaluating FC effectiveness, there were several concerns identified by FC reviews. First, the majority of FC studies focused on comparing FC and general non-FC conditions. However, as Lundin et al. (2018) indicated in their review, comparison studies' fundamental problem was in these kinds of studies. This means that the non-FC context, like the in-class, lecture-based teaching approach, was most likely to be treated as unsuccessful, and FC was seen as a solution. The effect of FC in improving student learning seemed to be taken for granted, commonly without explanation of the pedagogical design and implementation settings (Lundin et al., 2018). Therefore, future FC studies need to employ more alternative quantitative, qualitative, and mixed methods to understand the FC phenomena in depth.

Second, many FC studies evaluated influential factors based on small-size, local case, and short implementation period. For example, 26 of the 31 FC studies that Lundin et al. (2018) included in their review were locally situated in terms of the sample (commonly 20 to 40 students) or case (mostly in higher education) and focused on only one course. Such a small-scale design made the generalizability of these studies' results a likely issue. The fragmented knowledge contributions also showed that the development of FC's related field had yet to be stabilized (Lundin et al., 2018). Moreover, FC's positive effect at the beginning might not be sustained throughout the semester when students in non-FC conditions catch up by the end of the course (Evans et al., 2018). In order to see if the FC approach can be appropriately adapted in a broader-level implementation, higher quality studies focusing on longitudinal, large-scale, and numerous-courses designs are needed in the future (Akcayir & Akcayir, 2018; Karabulut-Ilgu et al., 2018; Lundin et al., 2018). Chen and colleges (2018) further proposed the critical potential of FC in education. It seems appropriate to further understand whether FC approaches work and, if so, in what types of situations and contexts.

Third, other issues might limit background information relevant to the implementation and practice of the FC approach. Some examples of this may include the difficulty of the content knowledge, instructors' teaching experiences with the pedagogy, or students' self-efficacy of using technology tools (Evans et al., 2018). However, the most recent FC studies failed to discuss these issues properly or provide sufficient related information. For example, since effective pre-class learning in FC has highly relied on students' self-regulation skills, it is an essential factor to be explored for the overall success of the FC practice (Cheng et al., 2019). Evans et al. (2018) also indicated the need to discuss faculty preparation issues for the FC approach. How to provide training to faculty in terms of technology usage, pedagogical design, and instructional supports may be important questions to answer as well as other factors in the success of FC.

The Definition of Learning Effects of FC Needs to Be Clarified

Results from the FC reviews raised a concern about the definition of learning effects used in FC studies to examine the FC effectiveness. For example, Evans et al. (2018) pointed out that inconsistency in terminology was a concern in the FC studies. Additionally, when discussing possible conceptual ideas related to the effectiveness of FC, most of the FC studies mentioned a mix of pedagogical strategies without providing a thorough explanation nor referring to the educational or learning theories framework. Blended learning and active learning were two of the ideas that were commonly brought up when examining factors associated with the effectiveness of FC (Lundin et al., 2018). While blended learning and active learning are considered effective strategies to support learning, few studies distinguish the impacts of FC from the effects of blended learning or active learning. It aligned with Akcayir and Akcayir (2018)'s argument that without identifying the definition of the conceptual terms, it is difficult to determine that the shown effect of FC was the result from FC or from other learning modalities.

In addition to the definition of learning effects, the type of indicators used to examine FC effects on learning could also be a potential issue. The retained FC reviews showed that academic performance (e.g., test scores and course grades) and self-reported data (e.g., participants' motivation and perceptions of the learning experience in FC situations) were the primarily common evaluation methods used in FC studies. However, Lundin et al. (2018) argued that most of the FC studies in their review chose inappropriate ways to examine the effects on student learning. They stated that survey data like pre-and post-test scores or course questionnaires could not provide an in-depth analysis of whether or what learning occurred in FC. Given that the purpose of FC was to promote higher-level cognitive skills like application, creation and behavioral change, lower-levels of assessment like recall in a test may not necessarily be considered as an appropriate way to evaluate the effects of the FC approach (Chen et al., 2018). To delineate FC's effectiveness, better sensitive indicators to measure the higher-level cognitive outcomes need to be developed (Chen et al., 2018).

Despite the Overall Positive Impact on Learning, the Varied Effects of FC should be Further Examined with Sufficient Qualitative and Quantitative Data

Most of the FC reviews discussing the effect of FC included in this study indicated that compared to the in-class or lecture-based approach, the positive impact of FC on students' learning outcomes had the effect sizes as small to medium (Chen et al., 2018; Cheng et al., 2019). Furthermore, lacking reviews that can evaluate the effectiveness of FC systematically may result from insufficient data or design information in previous FC studies. Hew and Lo (2018) indicated that scant FC studies provided the detailed and necessary information to conduct a qualitatively or quantitatively systematic review, which may be why only five FC reviews in the present study contained enough statistical data to conduct their studies using a software like Comprehensive Meta-Analysis (CMA). Besides the shortage of necessary data for statistical investigation from FC studies, the lack of information about the pedagogical design and implementation of FC makes it hard to perform qualitative analyses. Cheng et al. (2019) indicated that FC researchers seemed interested in reporting the effects of FC on students' learning outcomes, rather than examining the learning environment's actual design and implementation features (pedagogy). Without the essential information like the instructional strategies that applied the FC approach during the online and in-class time or the instructors'

teaching experiences related to the FC approach, it would be difficult to know which factors contributed to the overall impacts of FC. The above results suggest that more information is needed to support the effects of FC on teaching and learning.

While most FC reviews agreed on the overall positive impact of FC on learning, compared to non-FC conditions, in general, the effect size varied. Also, its actual effectiveness on learning remains debatable. More detailed qualitative and quantitative data are needed for further systematic analysis to provide high-quality evidence to form policy decisions on how best to use FC to enhance learning. A more solid theoretical background to distinguish FC from other learning approaches like blended learning and self-regulated learning is needed to determine what contributes to the learning effect in FC conditions. A stronger focus on the planned studies about evaluation or assessment of FC and the development of evaluation tools could provide experimental evidence of the impact of FC on teaching and learning. A broader-level study design that focuses on longitudinal, large-scale, and multiple courses is needed, as well.

The authors acknowledge some inherent limitations in this study. In general, the discussions in this study are based on the information and findings from the included 13 FC reviews. In other words, their study heavily relied on the quality of these review studies. Possible problems from previous FC reviews, such as inadequate literature search or improper analysis of the findings, can impact the quality and results of this study. Furthermore, although they tried to locate high-quality reviews in the first place, it was inevitable to lose detailed information of the primary literature. They developed a search strategy to search for FC reviews that were published in a major database. However, there is still a possibility that they may have missed some relevant FC reviews. Studies that were published after the search date in this review were not included either. In addition, the authors did not check if the included reviews selected the same FC studies. Therefore, FC reviews that focused on similar research purposes might partially consist of the same FC studies.

As stated by many scholars, the FC approach holds much potential, including more hands-on time with students and opportunities for active and collaborative learning. The authors are looking forward to seeing more creative adoption of FC as a pedagogical tool that can be used with other strategies, rather than substituting or replacing another. They hope to promote more effective and engaging practices in teaching that ultimately create a highly positive impact on student learning. There needs to be additional research in a broader range of learning contexts, while combining FC approaches with other instructional innovations to achieve such goals.

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Effects of a Problem-solving Framework Based on Engineering Design of Japanese High School Students

Koki TAMAKI
1721702 @ ed.tus.ac.jp
Doctor Student
Department of Mathematics and Science Education, Graduate School of Science,
Tokyo University of Science
1-3 Kagurazaka, Shinjuku-ku, Tokyo, 162-8601, Japan

Yuki WATANABE
wat @ rs.tus.ac.jp
Professor
Department of Mathematics and Science Education, Graduate School of Science,
Tokyo University of Science
1-3 Kagurazaka, Shinjuku-ku, Tokyo, 162-8601, Japan

Abstract

Recently, the development of problem-solving ability is emphasized. We taught Japanese high school students a framework of problem-solving based on Engineering Design. As a result, we found that students' awareness of problem-solving ability and self-assessment of problem-solving activities were improved. The students are considered to be suitable for the problem-solving framework based on Engineering Design.

Keywords: Problem-solving, Engineering Design, Information

1. Introduction

There has been a lot of discussion about the qualities and abilities that should be developed for the children of the future. For example, ATC21s has defined 21st century skills. The 21st century skills are defined as ten skills in four areas that are considered necessary for living in the 21st century. One of them is the problem-solving skills (Griffin et al. 2012). In addition, the OECD tested problem-solving skills for the first time in PISA 2003. These indicate that attention is being paid to the development of problem-solving skills.

Problem-solving skills have been defined in many ways. The OECD (2012) defines problem-solving skills as the skills to understand and cognitively process problem situations where the solution is not immediately obvious, as well as a proactive attitude toward the problem. Thus, the problem-solving skills are widely considered to be the skills to find an answer to a situation where the answer is not yet known.

1.1 Problem-solving in Japan

In Japan, education is standardized throughout the country based on the contents of the Course of Study issued by the Ministry of Education, Culture, Sports, Science, and Technology. The Course of Study is revised about once every 10 years to improve the content of education. In the Courses of Study, problem-solving skills are listed as one of the qualities that form the basis of learning. Therefore, it indicates that problem-solving skills should be taught throughout the school to improve the quality of educational activities and increase the effectiveness of learning.

Problem-solving skills are intended to be cultivated throughout school education. In school education, information science has been cited as an important subject for developing problem-solving skills (MEXT 2016). In Information I, one of the goals stated in the Courses of Study is "to acquire knowledge and skills about how to find and solve problems" (MEXT 2018). Problem-solving skills have been treated with more emphasis over the years.

This problem-solving skills has been practiced in various ways in Japanese information science. The following are some of the issues that have arisen through the practice in Japan. These include teaching knowledge and skills related to problem-solving and the integration of lessons on problem-solving skills into the teaching plan.

1.2 Develop Problem-solving

To develop problem-solving skills, many studies have been conducted and challenges have been identified. First, it has been shown that explicitly presenting and teaching skills is effective in developing problem-solving abilities(Mathee and Turpin 2019). In addition, Schoenfeld (2013) showed that it is necessary to develop a framework for problem-solving. In addition, there is a need to assess problem-solving skills (Griffin et al. 2012). Happner and Peterson (1982) developed the PSI to assess individual behavior and attitudes.

From this, it is clear that there is a need for an explicit framework for problem-solving as a skill. Engineering design has shown promise as a framework for problem-solving.

1.3 Engineering Design

We focused on engineering design as a problem-solving framework that improves problem-solving skills. It is said that there is no unified definition of engineering design (Li et al. 2016). For example, NGSS (2013) defines three types of behaviors that students who have mastered engineering design can perform (A) Define the problem to be solved. (B) Generate several solutions. (C) Optimizing the solutions to improve their quality.

The effects of engineering design on the problem-solving process have been examined in previous studies. Problem definition and information retrieval can lead to better problem solving (Atman et al. 2007). Although the time spent on problem solving activities is longer, it led to better problem-solving activities(Atman and Bursic 1996). However, no conclusion has been reached that it improves problem-solving skills (Li et al. 2016).

2. Purpose

We suggest that Engineering Design is effective in developing problem-solving skills. However, there is a lack of research that examines whether engineering design improves

problem-solving skills. The purpose of this study is to investigate the effect of teaching Engineering Design to high school students on their problem-solving skills.

3. Methods

3.1 Participants

In July of 2020, this study was conducted in 100 minutes at a private high school in Tokyo. The Participants were two classes of 82 third-year high school students, 54 (65.9%) boys and 28 (34.1%) girls, who were taking "Information".

3.2 Procedure

This practice was carried out according to the procedure shown in Figure 1. First, the participants answered a pre-questionnaire survey. The items of the pre-questionnaire were related to their perceptions of their problem-solving abilities. Next, the participants worked in groups of four or five on problem-solving activities. The problem-solving activity was conducted using a chat application on a smartphone. Afterward, the participants self-evaluated themselves and the group on the problem-solving activity. Then, we conducted a class to teach engineering design. In the class, we explained the framework of the problem-solving framework using PowerPoint and handouts. After the class, the students performed the same problem-solving activities as before and self-assessed the problem-solving activities in the same way. Finally, a post-questionnaire survey was conducted.

We prepared two types of group work topics. One was a problem-solving activity to think about what is needed to make life in a regular classroom more comfortable. I put a limit of 100,000 yen or less on the budget and asked them to think of something that could be installed in about two months. The second was a problem-solving activity in which students were asked to think of products that they would like to have in the school store. We put a limit on them to think of products within the range of what high school students can afford.

In teaching the problem-solving framework, the elements of the problem-solving framework based on engineering design were taught one by one. In addition, we taught the problem-solving framework by having the learners fill in the blanks on the handout that had blanks throughout the content. The framework of the problem-solving approach to be taught to the learners was developed based on Engineering Design (NGSS 2013, 2017) (Table 1). In teaching the problem-solving framework, the NGSS is written in English, it was translated into Japanese for teaching.

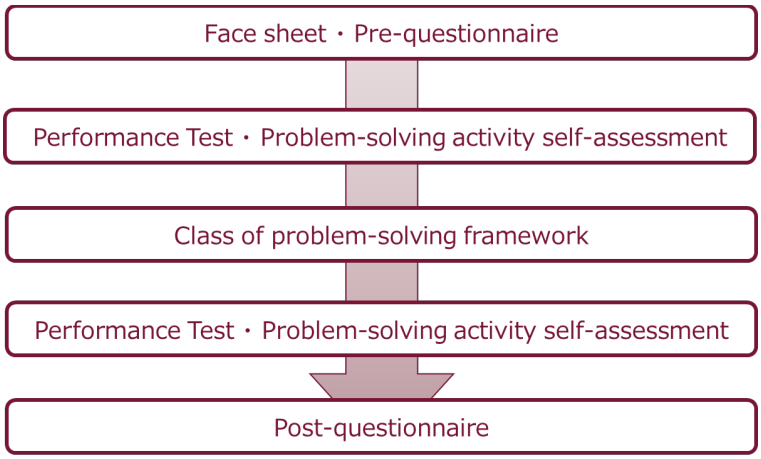

Figure 1. Procedure of research

Table 1. Framework for problem-solving based on Engineering Design

Define	Define a simple design problem that reflects the need, with specific success criteria and constraints on materials, time, and cost.
	・Understand what the problem is now. ・Understand what is required to solve the problem. ・Understand the conditions that must be considered when solving the problem.
Develop	Generate and compare multiple possible solutions to the problem based on how likely each solution is to meet the criteria and constraints of the problem.
	・To be able to generate multiple solutions ・Compare the degree to which each solution satisfies the problem. ・Share ideas to improve the solution.
Optimize	Plan and execute unbiased tests that control variables and account for failures in order to identify aspects of the prototype that can be improved.
	・Design tests to test solutions. ・Identify problems with the solution from test results. ・Collaborate to gather data for evidence.

3.3 Questionnaire

To investigate the changes in problem-solving skills, a questionnaire survey was conducted. First, a questionnaire survey on self-perception of problem-solving skills was conducted before and after the practice. In setting the items for the questionnaire, we selected 22 items out of a total of 47 items (32 items from the Problem-Solving Inventory (PSI) (Happner and Petersen 1982) and 15 items from the scale for measuring attitudes toward problem-solving (Emoto et al. 2005 in Japanese)).

In addition, self-evaluation of problem-solving activities was conducted. The self-assessment items included 9 items on the framework of problem-solving and 2 items on the self-confidence of the problem-solving activities. The students were asked to self-evaluate the degree to which they were able to perform problem-solving activities for their individual problem-solving activities and the problem-solving activities of the entire group.

In addition, a questionnaire survey was conducted after the practice to investigate the usefulness of the framework of the problem-solving approach. Five items were set as survey items to investigate the degree of usefulness through the problem-solving activities using the framework of the problem-solving approach.

4. Results

Based on the collected data, we investigated the impact of teaching the framework of problem-solving thinking on the learners. From the results of each questionnaire survey, those with missing values were excluded from the analysis, and data from 38 participants (46%) were used.

4.1. Problem-solving skills

The results of the pre- and post-questionnaires were used to measure changes in the perception of problem-solving ability. After processing the reversed items, Shapiro-Wilk's test for normality was conducted, but normality could not be confirmed. Therefore, Wilcoxon's signed-rank test was conducted on the pre- and post-questionnaires of self-perception of problem-solving ability (Table 2).

Table 2. Self-awareness of problem-solving skills

		Pre		Post		M_{post} - M_{pre}	Z		r
		M	*SD*	*M*	*SD*				
1.	I am able to look at a situation in different ways when solving problems. (R)	3.34	1.05	3.66	0.71	0.32	-1.87		0.35
2.	I am able to see things from different perspectives.	3.55	0.98	3.55	0.80	0.00	-0.02		0.00
3.	I try to think about the essence of things when I solve problems.	3.55	0.76	3.45	0.76	-0.11	-0.73		0.14
4.	Many of the problems I face are too complex for me to solve. (R)	3.03	0.79	3.26	0.95	0.24	-1.65	†	0.27
5.	When I make a plan to solve a problem, I am almost certain that I will succeed in doing so.	2.87	0.96	3.03	1.08	0.16	-0.92		0.15
6.	When I am faced with a problem, I am not sure that I can handle the situation. (R)	3.13	0.99	3.37	1.05	0.24	-1.52		0.23
7.	One of the first things I do when I notice a problem is to try to find out exactly what the problem is.	3.55	0.76	3.45	0.95	-0.11	-0.69		0.12
8.	When I am faced with a complex problem, I gather information so that I can define exactly what the problem is.	3.42	0.64	3.61	0.89	0.18	-1.29		0.24
9.	After I solve a problem, I do not analyze what went well and what did not go well. (R)	3.05	1.09	2.79	1.02	-0.26	-1.54		0.25
10.	When I am faced with a problem, I come up with as many ways as possible to handle it and think about them until I can't think of any more ideas. (R)	2.71	0.90	3.08	0.91	0.37	-2.38	*	0.41

11.	When I decide on an idea or possible solution to a problem, I do not take the time to consider the likelihood of success of each alternative. (R)	2.84	0.72	3.05	1.01	0.21	-1.28		0.24
12.	When I am faced with a problem, I stop and think before deciding on the next step. (R)	3.63	0.97	3.47	0.95	-0.16	-1.13		0.16
13.	I generally follow the first good idea that comes to mind. (R)	3.42	1.08	3.18	0.95	-0.24	-1.15		0.23
14.	When choosing a solution, I weigh the consequences of each alternative and compare them to each other. (R)	3.37	0.82	3.29	0.80	-0.08	-0.41		0.10
15.	I try to predict the overall outcome of implementing a particular solution.	3.18	0.77	3.50	0.80	0.32	-1.40		0.40
16.	When I try to think of possible solutions to a problem, I do not come up with too many alternatives. (R)	3.50	0.89	3.39	0.75	-0.11	-0.65		0.13
17.	I have a systematic way of comparing alternatives and making decisions. (R)	2.74	0.69	3.05	0.84	0.32	-2.00	*	0.41
18.	When confronted with a problem, I usually do not consider what external factors are contributing to the problem. (R)	2.79	0.66	3.18	0.73	0.39	-2.70	**	0.57
19.	When I am confused by a problem, one of the first things I do is to investigate the situation and consider all the relevant information.	3.11	0.73	3.42	0.76	0.32	-1.80	†	0.43
20.	Sometimes I don't stop to deal with my problems, I just mess around and move forward without taking the time to do so.	3.29	0.98	3.29	1.11	0.00	-0.04		0.00
21.	When I am working on a problem, sometimes I feel like I am groping or wandering and not getting to the real problem.	3.45	0.83	3.45	0.72	0.00	-0.07		0.00
22.	I sometimes make poor decisions and regret them later.	4.11	0.89	3.79	0.87	-0.32	-2.13	*	0.36

n=38, (R): Reverse score, 5-point Likert scale *†p<.100, *p<.050, **p<.010*

4.2. Problem-solving activities

Based on the results of self-evaluation of problem-solving activities, we measured the change in self-evaluation of problem-solving activities. As a result of Shapiro-Wilk's normality test, normality could not be confirmed. Therefore, Wilcoxon's signed-rank test was used for the pre- and post-questionnaires of self-perception of problem-solving skills (Table 3 for individual self-evaluation of problem-solving and Table 4 for group self-evaluation of problem-solving).

Table 3. Self-assessment of individual problem-solving activities

			Pre		Post		M_{post} - M_{pre}	Z		r
			M	*SD*	*M*	*SD*				
1.		I am satisfied with my problem solving.	3.21	1.06	3.55	1.02	0.34	-1.84		0.30
2.	Define	I was able to define a solvable problem that meets the needs of the problem conditions.	3.08	1.04	3.37	0.96	0.29	-2.07	*	0.34

3.		When defining the problem, I was able to identify what needs to be solved to be successful.	3.08	0.77	3.26	1.12	0.18	-1.79	†	0.29
4.		I was able to identify the constraints of the situation to be solved when defining it.	3.05	0.83	3.24	0.93	0.18	-2.64	**	0.43
5.	Develop	I can generate multiple solutions.	2.76	1.20	3.32	0.95	0.55	-0.83		0.14
6.		I can compare solutions in terms of success and constraints.	2.84	0.84	3.11	0.88	0.26	-2.03	*	0.33
7.		I can improve my solutions by sharing ideas.	3.03	1.09	3.37	0.98	0.34	-1.17		0.19
8.		I was able to discover improvements to the solution.	3.16	1.06	3.32	1.00	0.16	-0.26		0.04
9.	Optimize	I was able to improve the solution based on the improvement points	2.95	0.94	3.21	1.06	0.26	-3.41	†	0.55
10.		I was able to plan and execute surveys and other activities to discover improvements in solutions.	2.74	0.94	3.03	1.06	0.29	-2.11	*	0.34
11.		I think that my problem solving is better than others' problem solving.	2.58	1.14	2.92	1.09	0.34	-2.33	*	0.38

n=38, 5-point Likert scale *†p<.100, *p<.050, **p<.010*

Table 4. Self-assessment of the group's problem-solving activities

			Pre		Post		M_{post} - M_{pre}	Z		r
			M	*SD*	*M*	*SD*				
1.		We are satisfied with our problem solution	3.61	0.90	3.76	0.87	0.16	-1.24		0.20
2.		We were able to define a solvable problem that meets our needs for the problem conditions	3.47	0.94	3.61	0.87	0.13	-1.54		0.25
3.	Define	We have clarified what we need to solve to be successful in our definition	3.42	0.96	3.61	0.96	0.18	-1.22		0.20
4.		We were able to identify the constraints of the situation to be solved when we defined it	3.55	0.94	3.58	0.94	0.03	-2.45	*	0.40
5.		We were able to generate multiple solutions	2.92	1.11	3.24	1.06	0.32	-0.20		0.03
6.	Develop	We were able to compare solutions in terms of success and constraints	3.18	0.94	3.45	0.99	0.26	-2.06	*	0.33
7.		We were able to improve our solutions by sharing our ideas	3.24	1.01	3.63	0.96	0.39	-1.57		0.25
8.		We were able to discover improvements to the solution.	3.26	1.07	3.34	1.06	0.08	-0.06		0.01
9.	Optimize	We were able to improve the solution based on the improvements	3.47	1.04	3.39	1.01	-0.08	-1.17		0.19
10.		We were able to plan and carry out surveys and other activities that would enable us to discover improvements in our solutions.	3.11	1.07	3.34	1.06	0.24	-2.40	*	0.39
11.		We think that our problem solving is better than others' problem solving	3.05	1.02	3.29	0.94	0.24	-2.21	*	0.36

n=38, 5-point Likert scale **p<.050*

4.3. Usefulness of the framework

In the post-questionnaire survey, the evaluation of the problem-solving framework was conducted. The mean and variance of the results were calculated (Table 5).

Table 5. Usefulness of the problem-solving framework

		M	*SD*
1	I was able to understand the framework of problem-solving skills introduced.	3.76	0.85
2	I was able to solve problems using the introduced problem-solving framework.	3.42	0.89
3	The introduced problem-solving framework fits as a framework for problem solving.	3.61	0.82
4	I was able to solve problems easily by applying the framework of problem-solving skills introduced.	3.47	1.03
5	I was able to solve the problem better the second time than the first time.	3.79	1.12

n=38, 5-point Likert scale

5. Discussion

In this study, we investigated the impact of teaching a problem-solving framework based on Engineering Design on the students. From the results of the questionnaire survey, there was a change in the self-perception of problem-solving skills. It showed that the students' self-perception of their problem-solving skills changed, and they began to think that they were able to solve problems systematically after being taught the framework of problem-solving framework. In addition, they have come to believe that it is important to come up with multiple ideas for solutions when conducting problem-solving activities. They started to think about my own situation first when they started problem-solving activities. This was probably because they recognized the importance of defining the problem and developing ideas from the framework of problem-solving.

Self-evaluation of problem-solving activities also changed. In particular, the self-evaluation of problem-solving behavior related to define increased significantly. However, many items did not change in the self-evaluation of problem-solving behavior related to Optimize. Insufficient time for problem-solving activities and not being able to optimize problem-solving activities may have influenced the results. There was also a difference between the self-evaluations of individual and group problem-solving behaviors. This may be because they were not able to utilize the problem-solving behaviors that they were able to perform individually in their group problem-solving behaviors.

We found that the learners felt that the problem-solving framework was useful. However, they did not give it a high rating, indicating that it needs to be improved. The self-evaluation of the Optimize problem-solving activity also did not improve, indicating the need to improve the Optimize part in particular.

Several issues were found in this practice. First, there was no improvement in any of the problem-solving activities. In the framework of the current problem-solving approach, it was found that the "definition" problem-solving activity had a certain effect. However, the results for

"generation" and "optimization" were not sufficient to say that they were effective. Therefore, the framework of problem-solving and its teaching methods need to be improved.

The fact that the individual problem-solving activities could not be applied to the group problem-solving activities indicates that there is a need for consideration when conducting group problem-solving activities. In this study, we used smartphones, and we felt the need to provide support so that discussions using smartphones could be conducted smoothly.

In addition, there were some problems in the subject matter and time setting of the problem-solving activities. In addition, there were some comments from the chat logs that there was not enough time for the problem-solving activities, which suggests that there was not enough time for the problem-solving activities. In this practice, the time for each problem-solving activity was short because we had to conduct two problem-solving activities and a lesson on the framework of problem-solving in a short time. To give learners enough time for problem-solving activities, it is necessary to clarify the time required for the activities by conducting preliminary experiments.

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Faculty Perceived Barriers of Online Education at a Midwestern University in Ohio

Juenethia Tooson Fisher
City of Toledo

Berhane Teclehaimanot
University of Toledo

Many institutions have adopted best practices in the design of online education programs. However, the literature indicates that there is a need for continued research in the area of evaluating and examining online faculty satisfaction levels and self-perceived barriers in relation to online education. This study extended research conducted by Lloyd et al. (2012) and investigated faculty perceived (interpersonal, institutional, training/technology, and cost/benefit) barriers to online education. Statistical analysis revealed three major items: (1) faculty continues to experience barriers to online education; (2) faculty is receiving training and guidance in order to become more comfortable, and knowledgeable in online settings; and, (3) as faculty online experience increases, the perceived barriers decrease. Additionally, faculty provided detailed comments validating ongoing interpersonal, institutional, training/technology, and cost/benefit analysis barriers in online education. Higher education's online programs will benefit from intense professional development, training, as well as, open conversations including focus groups, composed of administration, faculty, and students.

Introduction

According to the *Condition of Education 2019* report, (McFarland et al., 2019) online enrollment in higher education continues to escalate with 5.5 million students participating in online education in fall 2017. Additionally, 2.2 million of those students, or 13 percent of the total undergraduate enrollment, were taking courses completely online. Between 2017 and 2028, the overall undergraduate enrollment is projected to increase to 17.2 million students. Additionally, from fall 1999 to fall 2017, faculty in higher education had an increase of 49 percent, from 1.0 to 1.5 million.

The *Condition of Education 2019* report is an annual verification, mandated by Congress to summarize the latest data on education in the United States. Local, state, and national governments continue to implement a host of initiatives, such as, improving student retention and completion rates, cultivating educational programs, increasing professional development activities, advancing technology, and development of academic leadership, etc. (Jolley et al., 2014). The exponential demand for online options in higher education directly affects faculty. Therefore, this current research will focus on understanding faculty perceived barriers to online education in an effort to advance research is this area.

This study expands on the research conducted by Lloyd et al. (2012), which stated that major factors affecting faculty's perceptions of online learning include: (1) interpersonal barriers; (2) institutional barriers; (3) training/technology barriers; and (4) cost/benefit analysis barriers. As online learning continues to be demanded by students, colleges have constantly increased online offerings due to the advancement of computer technologies. Faculty are tasked to accept new challenges via online education. Higher education would benefit from understanding major factors affecting faculty perceptions to online learning. A major benefit would include innovative guidance, and new opportunites for improvement in online education programs. "The advancement of online education has transformed the availability of higher education. Technology and adaptable curricula formats have expanded the speed, methods, and approaches in both traditonal and non-traditional education environments" (Fogle et al., n.d.), higher education continues to face changes.

As described by Windes and Lesht (2014), the dramatic changes which have been faced by higher education can be explained within the framework of Disruptive Innovation Theory. This theory suggests two types of technological change: supporting technological changes and disruptive technological changes. The authors note

that a supporting or sustaining innovation serves the needs of existing customers, provides some enhancements; however, it does not result in major changes to the market or its audience. In contrast, a disruptive innovation, ultimately replaces services or products because they are more accessible to a population of customers, enabling new companies to develop and then dominate the industry. Therefore, as emphasized by Windes and Lesht (2014):

> Many have pointed to online education as a disruptive innovation within higher education. Students that were not well served by traditional colleges have seen their options increase as the number of online courses and programs has grown. While initially resistant, many institutions of higher education are now attempting to compete with early adopters by developing online programs in order to reach this underserved market. (p. 1)

The Ohio Faculty Council (OFC) which represents all of the faculty at all of the four-year public universities in the state of Ohio, advised that higher education in Ohio is at a crossroad, and must make it easier for students to attend college and earn quality and affordable degrees. "Today, 45% or more of working age adults in other states like Massachusetts, Maryland and Virginia have two- or four-year degrees compared to only 36% of working age adults in Ohio" (Ohio Faculty Council [OFC], 2014, para. 2).

A major strategy for Ohio, as noted by OFC includes a personalized academic program of study, which will ideally include the option of courses from Ohio Public institutions delivered in the online learning format. However, throughout the literature, it is noted that faculty continue to resist online education.

Statement of Problem

Faculty continue to express fears and concern about online education (Davis & Jacobsen, 2014; Eickholt, 2016; Fogle et al., (n.d.); Gillett-Swan, 2017; Glass, 2017; Reid, 2014), and they are reluctant to teach in the online format. Online education which has been recognized as an emergent and profitable field, has developed into a permanent fixture in mainstream higher education (Luongo, 2018). Students and employers continue to laud online education due to the fact that location and scheduling issues are expunged. Higher education administrators continue to examine cost effectiveness and surges in enrollment due to evolving technologies. As reported by Seaman et al. 2018:

> The proportion of the higher education student body taking advantage of distance education courses has increased each of the last four years. It stood at 25.9% in 2012, at 27.1% in 2013, 28.3% in 2014, and 29.7% in 2015. (p. 11)

Even after a decade of significant growth in the number of universities with online offerings and students taking these courses, the level of uncertainty in relation to online learning amongst faculty continues to remain high (Allen & Seaman, 2016).

Wingo et al. (2017) states that in the United States, faculty are being tasked to teach online at an outstanding rate. Faculty are hesitant and reluctant to embrace online teaching due to: (1) interpersonal barriers; (2) institutional barriers; (3) faculty training/technology barriers; and (4) cost/benefit analysis barriers (Lloyd et al., 2012). There are numerous policy items and issues that administrators and faculty need to discuss in relation to online environments. Obstacles faced at various stages of online education noted by Berge and Muilenburg (as cited in Reid, 2014) include: administrative structure, legal issues, organizational change, technical expertise support, student support services, access, threatened by technology, faculty compensation and time, social interaction and quality, evaluation/effectiveness (p. 384)

Faculty are increasingly challenged to rethink their underlying assumptions about teaching and learning online, and the roles they take as instructors (Luongo, 2018). Luonogo also reminds us that perceived lack of institutional and departmental support is one of the biggest deterrents to teaching online. In the meantime, the competition has created other avenues such as edx and coursea. Understanding faculty perceived barriers to online education might assist in reducing barriers in this environment.

Purpose of the Study

The purpose of this study is to understand if, and why faculty members have perceived barriers to online education. Based on a review of faculty perceived barriers in higher education (Allen & Seaman, 2016; Capra, 2011; King & Arnold, 2012; Lloyd et al., 2012) more research is needed to comprehend this topic. This descriptive quantitative study intended to use the results to assist institutions as they cultivate training programs, and faculty recruitment policies for online education, in order to meet the growing demand for this type of instruction. The findings of this study contributed to the body of knowledge in the fields of faculty development, online learning, and higher education administration.

Methodology

Some researchers use the term survey research to denote almost any form of descriptive, quantitative research (Leedy & Ormrod, 2013). This current study intended to use survey research to acquire information about one or more groups of university faculty and their characteristics, opinions, attitudes and previous experience with online education by asking questions and tabulating their answers. This study also intends to investigate the relationship between faculty members' demographic characteristics and interpersonal, institutional, training/technology, and cost/benefit analysis barriers. Questions will be answered by the use of an online self-report survey instrument and the responses will be analyzed quantitatively.

Research Questions

The study attempts to answer the following research questions:

1. Is there a significant difference in faculty perceived institutional barriers for online education based on full-time status?
2. Is there a significant difference between faculty perceived institutional barriers for online education and years of online teaching?
3. Is there a significant relationship between faculty perceived institutional barriers for online education and age?
4. Is there a significant difference between faculty perceived interpersonal barriers and gender?
5. Is there a significant difference in faculty perceived technology barriers and previous online courses taken related to online teaching?

Instrument

The survey instrument proposed as the foundation for this study was created by Lloyd et al. (2012) for a study of faculty perceived barriers of online education at North Georgia College & State University. "There are advantages to using existing instruments, particularly if they have already been validated and reported to be reliable. Reusing an existing survey may also allow for an additional point of reference and comparison" (Eickholt, 2016, p. 3). The noted survey instrument was "pilot tested twice in order to assess the face validity and clarity of the questions (pilot test #1) as well as the ease of use of the web-based survey tool and reporting formats (pilot test #2)" (Lloyd et al., 2012, pgs. 3-4). Lloyd et al. (2012) sent three email requests for participation to faculty members, an informed consent, and a URL to access the online survey. It was also noted that all procedures were conducted in accordance with, and approved by the North Georgia College & State University's Institutional Review Board.

This present-day research study will augment the 37-item questionnaire that was constructed, distributed, and used in the online survey at North Georgia College & State University by the above noted researchers. This researcher received an email confirmation to use the North Georgia College & State University's online survey (S. Lloyd, personal communication, September 1, 2014).

The instrument for this present study was a self-report questionnaire with four sections. The first section of the questionnaire contained seven questions that measured online faculty members experience and perception of online education. The second section contained 21 questions that measured faculty perceptions of barriers to online education on a Likert scale. The Likert scale asked the participants to rate the extent that they strongly disagree, disagree, agree, or strongly agree with the various statements in relation to barriers towards online teaching and learning. The third section was an open-ended question, which asked the participant to list their experience with

other barriers to online education. Finally, section four was the demographics area, which contained six questions.

The population for this study included faculty teaching at least one face-to-face or online course during the academic year 2019/2020 semester at a four-year degree-granting public Midwestern University. This included those teaching undergraduate and graduate degree programs, approximately 800 participants.

Data collection

During the academic year 2019/2020, the Midwestern University's Office of Institutional Research sent the recruitment email via the university's e-mail system (online) to all faculty teaching at least one face-to-face or online course and invited them to participate in the study. The email contained a consent letter informing the faculty members of their rights as participants. If the faculty member elected to participate, they clicked a link to Qualtrics that was available for them to complete the anonymous questionnaire.

Data analysis

The statistical tests used included the following:

One-way ANOVA – this exploration includes only one independent variable with more than two levels.
Independent samples *t*-test – Compares two sample means to determine whether the population means are significantly different.
Pearson correlation – an analysis of the linear relationship between two variables, called the Pearson *r*.

Results

During the academic year 2019/2020, the Midwestern University's Office of Institutional Research sent a recruitment email via the university's email system (online) to faculty teaching at least one face-to-face or online course, and invited them to participate in the study.

Listed are the colleges within the Midwestern University, which were sent an invitation to participate in the study: Arts and Letters, Business Innovation, Education, Engineering, Health and Human Services, Law, Natural Sciences and Mathematics, Nursing, and Pharmacy and Pharmaceutical Sciences. Of the 792 faculty members who were sent an email invitation, 115 faculty members completed the survey from October 29, 2019 until December 4, 2019. A response rate of (14.5%) was the result. The demographic characteristics of the participants are illustrated in Table 1, which include gender, faculty status, academic rank, experience with online education, perceived level of comfort and proficiency with technology for online teaching, and years of online teaching.

Table 1
Demographic Characteristics of Respondents

Demographic		N	% of Sample
Gender			
	Male	39	33.9%
	Female	58	50.4%
	Prefer not to answer	9	7.8%
	Missing	9	7.8%
Faculty Status			
	Full-time	78	67.8%
	Part-time	24	20.9%
	Missing	13	11.3%
Academic Rank			
	Professor	22	19.1%
	Associate Professor	18	15.7%
	Assistant Professor	14	12.2%

Demographic	N	% of Sample
Lecturer	23	20.0%
Visiting Instructor	1	0.9%
Other	28	24.3%
Missing	9	7.8%
Experience with Online Education		
No Experience	40	34.8%
Taught Online Course	69	60.0%
Missing	6	5.2%
Perceived Level of Comfort and Proficiency with technology for online teaching		
Not Comfortable	13	11.3%
Sort of Comfortable	47	40.9%
Very Comfortable	47	40.9%
Missing	8	7.0%

Demographic Characteristics of Respondents (continued).

Years of Online Teaching		
Never	39	33.9%
1-4 Years	28	24.3%
5-8 Years	14	12.2%
8+ Years	24	20.9%
Missing	10	8.7%

Research questions. In addition to providing data analysis for the research questions, respondents provided rich qualitative data in the open-ended question in the survey.

Research question #1: Is there a significant difference in faculty perceived institutional barriers for online education based on full-time status? As shown in Table 2, an independent samples t-test was used to determine whether differences existed in the mean score for perceived institutional barriers based on full-time and part-time faculty rank. As shown in Table 2, there were no statistically significant differences in the score ($p<.05$) for any perceived institutional barriers.

Table 2
Independent Samples t-test by Institutional Barriers Full/Part-time

	Full-time		Part-time			
	M	SD	M	SD	t(99)	p
Perceived Institutional Barriers	26.8	5.5	26.7	4.3	0.11	>.05

Comment from a part-time instructor:

> I am a part-time instructor with full-time (50+ hours) administrative job. I teach a mixed class of in-class and distance learners. My method of teaching involves several hands-on, team workshops. It is very difficult to give the DL's the same experience with the hands-on exercises. I did try to take a course in on-line teaching but it involved more time than I could dedicate due to full-time responsibilities and it seemed to start at a level above my starting point.

Comment regarding academic support: "If a Chair is not supportive of online course development, they don't encourage their faculty to design courses."

Research question #2: Is there a significant difference between faculty perceived institutional barriers for online education and years of online teaching? As shown in Table 3, a One-way ANOVA test was used to determine the difference amongst the four groups (never taught online, 1-4 years, 5-8 years, and 8+ years). There were no statistically significant differences; however, the 8+ years group had a lower mean, as compared to the other groups.

Table 3
ANOVA Institutional Barriers Based on Years of Teaching Online

	Never taught online		Taught online 1-4 years		Taught online 5-8 years		Taught online 8+ years			
	M	SD	M	SD	M	SD	M	SD	F (3, 100)	p
Perceived Institutional Barriers	28.1	4.9	28.6	4.6	26	3.5	22.7	5.4	8.19	0.001

One respondent has been teaching since 2002:

> The Online Learning division should be marketing our programs. Many UToledo online programs are certified through Quality Matters. UToledo online courses offer direct access to the instructor, usually within 24-48 hours, as is not the case with on campus courses.

One respondent commented on the benefits of online education:

> Online courses help students beyond the expected coursework in that scheduling/planning, time management and project management are learned, providing enhancement of skills for undergrads and graduate students.
>
> Online learning provides help lines, tutorials, and a myriad of other support materials for students. This also improves student communication skills, both verbal and written. I see no down side to online teaching, other than an instructor who does not put in the time and energy to fully transform their on-campus course into a quality online course. I have been teaching online since 2002. I have used WebCT and Blackboard, but I am also familiar with Canvas, Moodle and many others.

On the other hand, a respondent with no online teaching experience proclaimed:

> I would like to teach, but getting over the first hump is a little scary. If I had more hands on support from other faculty who have taught online or modules that could improve my online skills, I think that would help.

Additionally, some respondents did not have any barriers: None. In fact, I get far more participation in online classes than I do face-to-face.

This respondent favored face-to-face instruction: There is empirical evidence that face-to-face instruction results in better learning than the disembodied online experience.

*Research question 3: Is there a significant relationship between faculty perceived institutional barriers for online education and age? A*s shown in Table 4, a Pearson correlation was used to determine whether there was a relationship amongst age and perceived institutional barriers. The test showed that a negative relationship existed. As age increased, perceived institutional barriers decreased. Or, as age decreased, perceived institutional barriers increased.

Table 4
Pearson Correlation by Institutional Barriers Based on Age

Measure	1	2
1. Age	-	
2. Perceived Institutional Barriers	-0.15	-

Research question 4: Is there a significant difference between faculty perceived interpersonal barriers and gender? As shown in Table 5, an independent samples *t*-test was used to determine whether differences existed in the mean score for perceived interpersonal barriers based on gender. As shown in Table 5, there were no statistically significant differences in the score ($p<.05$) for any perceived institutional barriers.

Table 5
Independent Samples t-test by Interpersonal Barriers and Gender

	Male		Female			
	M	SD	M	SD	t(94)	p
Perceived Interpersonal Barriers	14.2	3.5	14	3.7	0.83	>.05

Faculty illustrate some of the perceived interpersonal barriers that exist based on gender:

> As a Black female professor, students are less respectful to me than their white and male counterparts. They either plead for me to change their grades and if I maintain the integrity of my grading policy, they retaliate by writing negative evaluations. They do address me by my first name and or attempt to question the integrity of my expertise in the subject.

This comment discussed difficulties of online environments:

> I am resistant to online teaching because I feel strongly that the most valuable parts of college are meeting your classmates and professors, having to show up on time, and the dialogue that happens in class. I associate online-heavy curricula with unaccredited, for-profit universities, not with legitimate institutions. I enjoy students and want to get to know them which is difficult in an online setting . I also sense that the emotional labor component of teaching is extremely limited for online-only faculty. They don't have to stand in front of students or develop relationships with students, so they don't get asked for letters of recommendations, advice on job interviews, questions, etc. that face-to-face faculty do. My sense is that students don't take online courses as seriously as their face-to-face classes. Students will freely admit even to faculty that they take online classes because they are "easy" or because they can use the book during tests. That is highly problematic.

This respondent commented on instructor creativity, morale, and motivation:

> I think that some of the barriers listed about being impersonal can be true, but it is up to the instructor to ensure that the online class is finding ways to make it more personable. However, this also makes it a much more time consuming class to teach. It is definitely harder to engage students who are only taking an online class so they don't have to "show up" to a physical class. That mindset can be a barrier for instructors. Adjunct instructors might also feel less connected to the department and other instructors if they are not physically present. Having a connection with other faculty in the department can help with creativity, morale, and motivation.

Research question 5: Is there a significant difference in faculty perceived technology barriers and previous online courses taken related to online teaching? As shown in Table 6, an independent samples *t*-test was used to determine whether differences existed in the mean score for perceived technology barriers based on if the respondent has taken previous online courses in relation to online teaching (yes or no). As shown in Table 5, there were no statistically significant differences in the score ($p<.05$) for any perceived institutional barriers.

Table 6
Independent Samples t-test by Technology Barriers and Previous Courses

	Yes		No			
	M	SD	M	SD	t(103)	p
Perceived Technology Barriers	4.1	1.4	4.3	1.2	-0.69	>.05

This respondent discussed technology barriers:

It sometimes feels more difficult to create meaningful, active discussions or activities to engage students. There are always options to use discussion boards, and have students create short videos, however, it feels to me there is always a challenge in engaging students online, when compared to in-classroom.

Comments below state optional forms of technology:

If you have a good platform like Zoom where you can see each other and divide into virtual small discussion groups, share your screen, and do the class in real time it is a really great way to teach and learn. It's more inclusive for distance learners. I do think that there is something different that happens in a face to face situation that is in person that is different from the online. I am not sure if it's different enough that the lack of face to face is a barrier. It might be for better to have blended classes some online class times and some in person especially for health and human services were dealing with people in person is part of the profession.

Other technology concerns: Poor support of computer hardware and software from university needed for effective course development and monitoring and availability of training to use online system.

Conclusions

The purpose of this study was to understand if, and why faculty members have perceived barriers to online education. Results indicated that faculty continues to experience various barriers online. However, faculty report being comfortable in the online environment, and continue to embrace this form of educational delivery.

Faculty in this study, based on the specific research questions, do not have perceived institutional barriers based on full-time status. Results also revealed that as faculty online experience increases, faculty perceived institutional barriers decrease. Additionally, there are no perceived interpersonal barriers based on gender; and, no perceived technology barriers based on previous online classes taken in relation to online teaching. There is a relationship amongst age, and perceived institutional barriers; as age increased, perceived institutional barriers decreased.

On the other hand, faculty comments provided rich, practical, and extensive documentation of ongoing interpersonal, institutional, training/technology, and cost/benefit analysis barriers. The study also highlighted additional critical barriers experienced by faculty, which included the lack of student preparation in the online environment, issues with learning management systems, and questionable support of academic leaders towards online education. The online environment has become even more integral to scholarship based on the pandemic health concerns throughout the world.

Online education is no longer, just a preference. Administrators, faculty, and students are on notice as to the urgency, and significance of this form of educational delivery. Planning must also include transformation of face-to-face courses to online delivery. Additionally, faculty will benefit from intense professional development, training, as well as, open conversations including focus groups, composed of administration, faculty, and students. Online education continues to evolve, and higher education continues to advance, and embrace this challenge.

In summary, this research study sought to understand why faculty continue to express fears and concerns in online environments. The data provided generous examples of current interpersonal, institutional, training/technology, and cost/benefit analysis barriers. The significance of the study provides administrators with guidance, and opportunites to improve current practices in the development of online education. Guidance includes understanding the technology acceptance model, online education, pedagogy, and tackling the critical barriers from question #29. The domain of education has changed forever; and, it continues to face new challenges worldwide. This research provides evidence that it is imperative to address faculty perceived barriers in the "everchanging digital world" called online education.

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TraceMe + Pedagogical Agent = Morgan: Personalized Learning With AI

Fatimah Wirth, Ph.D.

Abstract

Online courses are often structured using a cookie cutter approach and even when they are personalized, they are done based on instructor/instructional designer experience. In this research study, the learners' paths was traced throughout the online course. Georgia Tech Professional Education (GTPE) collaborated with Professor Alain Mille from the French National Center for Scientific Research and France's Universite Numerique and Pierre-Antoine Champin from Claude Bernard Lyon 1 University in France and the LIRIS research center and used their proprietary software called TraceMe to collect data in a Georgia Tech Professional Education (GTPE) course. The research question addressed was how learners navigate through an online course. The findings from this research study will help identify trends/paths that can be used to restructure curriculum and presentation of content. Understanding the learner's navigational and interactivity patterns will inform effective course design (Stein, 2014). The findings will also help create an artificial intelligent pedagogical agent that provides a personalized path. The AI pedagogical agent will pop up at the point where the learner is frustrated or stuck.

Introduction

The Covid-19 pandemic has forced everyone to learn in new ways. It has ripped us from the traditional classroom environment and forced us to think of education and learning in new and novel ways which may have been unthinkable pre-Covid-19.

Although this research study predates the Covid-19 pandemic, it even more relevant now. Once the research data had been analyzed, the Georgia Tech Professional Education (GTPE) researchers will be able to determine how the learners navigate through a course based on the trace data collected. This will help identify trends/paths that can be used to restructure curriculum and presentation of content. Understanding the learner's navigational and interactivity patterns will inform effective course design (Stein, 2014). Georgia Tech Professional Education collaborated with Professor Alain Mille from the French National Center for Scientific Research and France's Universite Numerique and Pierre-Antoine Champin from Claude Bernard Lyon 1 University in France and the LIRIS research center and used their proprietary software called TraceMe to collect data in a GTPE course.

The aim of this research project was to trace the path that a learner takes during an online course session using javascript applied to each course page within the Learning Management System. The path that is traced includes how the student peruses the course menu and the content within a course. The data collected from the trace of the learner's path through the online course can be beneficial in that the researchers will be able to find out where learners have issues within the course. The issues may be due to navigation, instructions or course content. As a result, the researchers will be able to discover trends or themes when the data is coded. These trends or themes will lead to better online course structure, course content and course navigation. This will

then improve the quality of the online courses so that participants get a more positive and beneficial online course experience.

Research Questions

The aim of this research project is to trace the path that a learner takes during an online course session using javascript applied to each course page within the Moodle Learning Management System (LMS). The path that is traced includes how the student peruses the course menu and the content within a course. This will allow us to identify areas within the course that need improvement.

The research questions investigated in this research study were as follows:

- Identify where and when learner engagement drops off
- Identify where content needs to be clearer or re-emphasized

An IRB protocol was submitted and approved before research and data collection started.

Literature Review

New challenges in information technology has forced institutions of higher learning to rethink education. Many institutions have turned to Artificial Intelligence (AI) to improve education. According to Yolvi, et al.:

> The formats based on artificial intelligence promise a very substantial improvement in education for all the different levels, with an unprecedented qualitative improvement: providing the student with an accurate personalization of their learning tailored to their requirements, managing to integrate the various forms of interaction human and information and communication technologies.
>
> (Yolvi, et al., 2019, p.536)

Artificial Intelligence creates computing systems that have the ability to learn from information in its environment and provide adaptive behaviors to assist learning. For the past 30 years, many institutions of highly learning have focused on creating AI based systems to mimic human tutoring. These systems are highly autonomous, interactive and adaptable (Qin, et al., 2020).

AI can also assist those with intellectual disabilities. These learners need a wide range of learning needs and do not learn in a linear or hierarchical way. The use of artificial intelligence tools for education can help move a student from a negative state to a positive state of learning. Students who are frustrated or stuck at a certain place in a course can be nudged to move into a more positive state of engagement. (Standen, et al., 2020)

However, so far, even though there may be intelligent tutors powered by AI, there is yet not a single one that provides just-in-time assistance where the AI pedagogical agent actually pops up at the time of frustration or being stuck in one place in a course and lets the learner know that there are other pathways that they can follow in order to get unstuck. This research study aims to do just that.

Methodology

The instructional designer reached out to at least three instructors teaching Georgia Tech Professional Education online courses in Fall 2017. An instructor was chosen based on the

interest of the professor to participate and the ease of navigation of the course. The duration of the subject participation would be the duration of the course.

A week before the start of the course, the students in the course were sent a Qualtrics survey asking for voluntary participation in the research study. The students had to enter their first name, their last name and their email addresses. A consent form was attached to the email. In addition, before taking the background or end of course survey, the participants in the research study were provided with verbiage that said that if they took the survey, then they were consenting to taking part in the research.

The students first name, last name and their email address were asked so that the sample population would be identified. Once this population has been identified, their actual trace data will be anonymous. Their names will not be attached to the trace data in any way. The system will generate a random ID for each student based on CAS authentication. So each time the student logs into the course, the same random ID will be used for the student. There will not be a key or any document that will link the names to the random ID generated at any point during the study.

A new role called "Non Participant" was created for all those who did not fill out the survey or who did not want to participate in the research study. The new role was manually added to each student who did not want to participate. By adding this role, these students would not be tracked. These students would therefore have two roles, namely the Student role and the Non Participant role. This exclusion from participation in the study was created via the use of an HTML block in the Moodle Learning Management System used by Georgia Tech Professional Education. The HTML block would be called KTBS. The Non Participant role will ensure that the students who do not wish to participate will not see the KTBS HTML block when they logged into their course. This would mean that they will not participate in the study. The students who agreed to participate in the research study will see the KTBS HTML block when they log into their course. In addition, they will see a large red dot on the top right of the page.

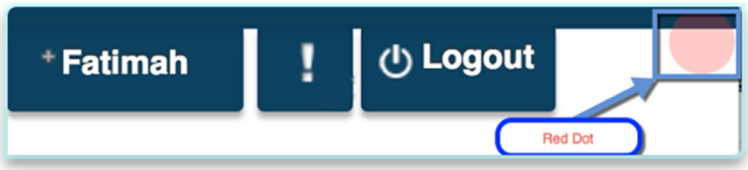
When the students who had agreed to participate in the research study logged into the course, their every action in the course would be traced. This was an automatic process and the students would not have to do anything to initiate the process. If the students who had agreed to take part in the study did not want their actions traced, they can click on the red dot. The green dot will then become a red dot. This will mean that their actions in the course are not being tracked. If they log out of the course and then log back in, then the green dot will automatically appear again. This means that they will have to uncheck the check box again if they do not want to be tracked. The tracing of the data will not impact or change the normal user navigation or course setup in terms of activities and assessments.

The students were informed that there were no known risks for participating in the study. All student information would be kept confidential. All records would be kept under a code number and not by student name. However, students were warned that data may exist on backups or server logs after the end of the research project. All data would be deleted three years after the completion of the study.

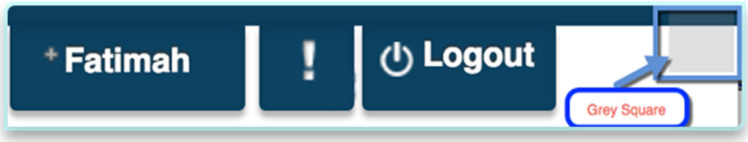
The students were also informed that the trace data would be on the Amazon Cloud server. The data collected would be anonymous and only the researchers would have access to this server. Only the researchers would be able to download the data as a CSV file.

The students who agreed to participate in the course were identified through the response to the survey and given access to a consent form. In the consent form, students were notified that the software called “TraceMe” would be activated when they logged into the course. They would

see a red dot next to their names on the top right and that signified that their actions in the course was being traced (see image below).



These students were also informed that if they wished not to be traced on a certain day or if they no longer wished to have their actions in the course traced, then they could click on the red dot next to their names on the top right. The red dot would then turn into a grey square and this would denote that they were no longer being traced (see image below).



The students who did not wish to participate would not have access to the software and hence would not see a red dot next to their names on the top right. They would participate in the course as any other student in an online course would.

In addition, the participants will have to fill out a background survey and an end of course survey. The background survey will collect demographic information of the participants. The end of course survey will ask questions about the course design and navigation.

The background data will be collected once at the beginning of the course through the background survey. The end of course survey data will be collected once at the end of the course through the end of course survey. The end of course survey will determine the difficulty level of the content and the navigational ease of the course. The data collected from the background and end of course surveys will be correlated to the trace data. For example, the trace data and the background data can be correlated to show how younger participants navigate versus how older participants navigate through the course. There may also be other correlations in terms of navigation through the course such as gender, educational background, reason for taking the course, etc. The trace will be continuously sending data on student navigation of the online course to the server. This data will be captured for the entire duration of the course. The data collected will assist the Georgia Tech Professional Education instructional designers to figure out where students get stuck within a course and what can be done to alleviate that. There could be follow up interviews with each student who had difficulties to find out why they got stuck and what would have made either the navigation or the content better meet their needs.

Course Design

The Learning Management System at Georgia Tech Professional Education at the time of the research was Moodle hosted by Moodlerooms. The course chosen for the research project was VET^2: Military Transitions to the Workforce. The course was chosen based on the fact that it had a clean interface and was easy to navigate. The course was also designed based on the

Standards from the Quality Matters Higher Education Rubric, Sixth Edition and had enough activities to make the course engaging.

The tracing software that we piloted was developed by Dr. Alain Mille from Liris (Trace-Based System - a project of the TWEAK Team) and Pierre-Antoine Champin from Claude Bernard Lyon 1 University in France. The trace engine was installed on a server and javascript code was appended to each course page in Moodle. The trace would be automatically activated as soon as the learners who had agreed to participate in the research study logged into their course. The tracing software then would record and archive all paths taken by the learners. The tracing of the data will not impact or change the normal user navigation or course setup in terms of activities and assessments.

The data collected from the trace of the learner's path through the online course can be beneficial in that the researchers will be able to find out where learners have issues within the course. The issues may be due to navigation, instructions or course content. As a result, the researchers will be able to discover trends or themes when the data is coded. These trends or themes will lead to better online course structure, course content and course navigation. This will then improve the quality of the online courses so that participants get a more positive and beneficial online course experience.

Data Collection

Data was collected from the background survey, the end of course survey and the trace from the TraceMe software. Data from the background survey and the end of course survey will be analyzed quantitatively and/or qualitatively. These data may also be exported to qualitative and/or quantitative software packages.

Dr. Champin created a Pilot HTML block in the course, to host the script that would collect the data when the student who had agreed to participate in the research project logged into the course. The student would see the red dot on the top right of the page when data was being collected.

The trace data collected from the Amazon Cloud server would be analyzed qualitatively and/or quantitatively. The data is anonymous and only the researchers have access to this server. In addition, the trace data would be exported to qualitative and/or quantitative software packages. Open coding would be used to discover trends, themes or confounding variables within the qualitative data collected. The data may also be cross-tabbed across multiple data sources (e.g. background survey, end of course survey and trace data from plugin) in order to discover trends, themes or confounding variables. The tracing of the data will not impact or change the normal user navigation or course setup in terms of activities and assessments.

The data collected from the participants of the research study will be kept confidential to the extent allowed by law. Participant records will be kept under a code number and not by name. Participant records will be kept in a locked file if printed and on a secure desktop or laptop if electronic. The data on the desktop or laptop will be kept secure by locking the desktop or laptop screen with a user login and password. When the desktop or laptop computer is not in use the screen will be locked. Only the researchers will have access to these files - printed and/or electronic. Participants in the research study will only be identified by number. Data correlation will use this number to match data from various sources to the participant. Researchers will share data and collaborate on a private Office 365 site. The site will only be available to the

researchers. All data (printed and electronic) will be destroyed three years after the completion of the study.

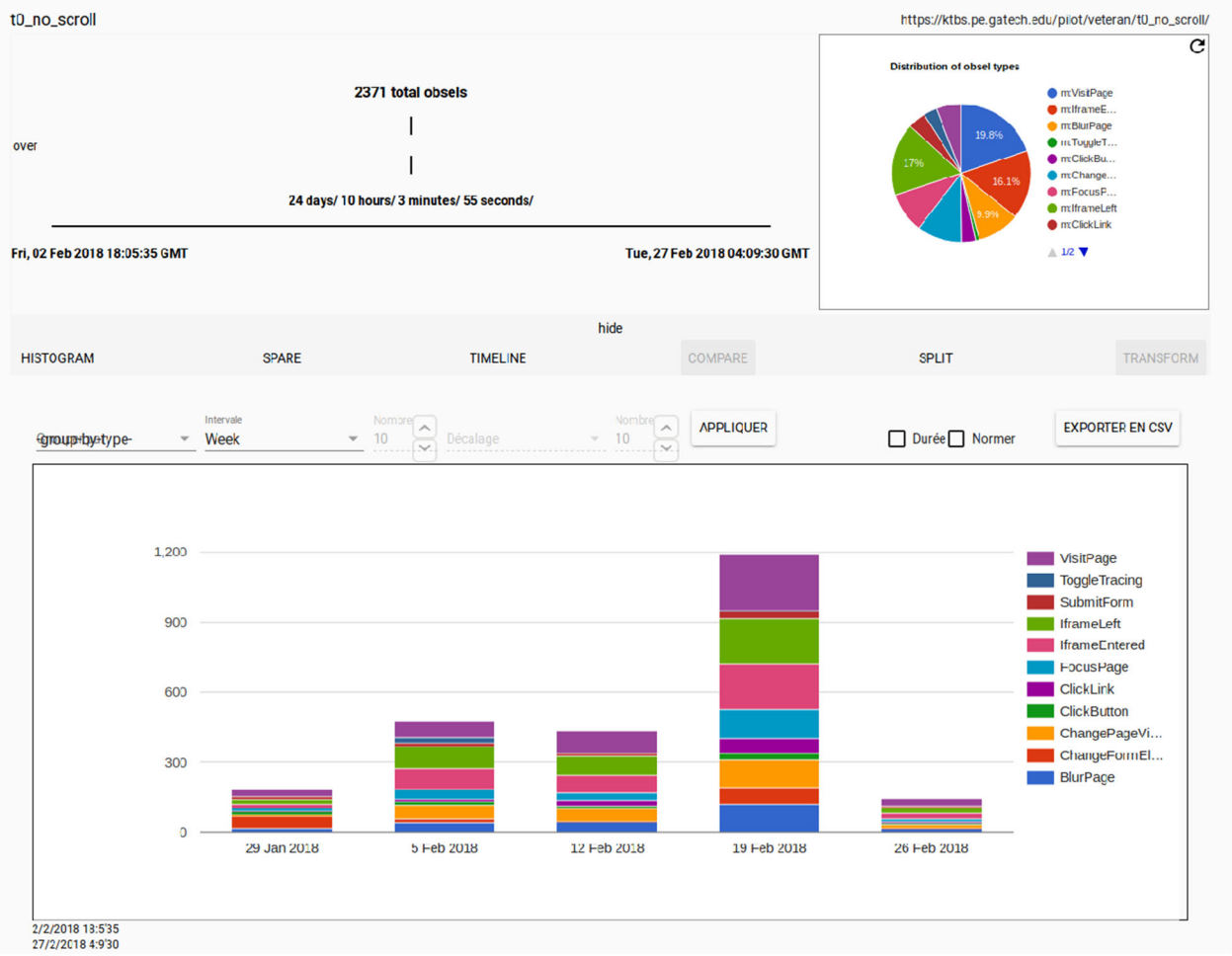
Data Analysis

Data collection took place in Spring of 2018. The chosen course, VET^2: Military Transitions to the Workforce, went live on February 5, 2018. There were 26 students in the chosen course and all 26 students agreed to take part in the research study. The students were given 6 weeks to complete the course which had 4 modules, 4 end of module quizzes, 5 assignments and 7 videos to watch. Data was collected on an AWS server. The Amazon Cloud external server only collected anonymous data. The researchers had access to this server and were able to download this data as a CSV file.

In just 24 days, 2371 pieces of data was collected. The data collected included visiting a page, submitting an assignment, clicking a link, clicking a button, changing page view.

Figure 1

Preliminary data obtained from VET^2: Military Transitions to the Workforce course.



Of more interest however, was how the students were making their way through the course and where they got stuck or spent the most amount of time. However, data collection and data analysis had to stop before the GDPR rules went into effect on May 28, 2018 as the researcher collecting the data was Pierre Anton Champin who resided in France. Pierre handed over the data to the researcher in the United States and data analysis has stalled since then because of the new GDPR rules.

Work in Progress

After data collection ceased due to GDPR restrictions, data analysis also ceased. This is due to the fact that the researchers who would be analyzing the data were from France. Currently there are more than 40,000 bits of data waiting to be analyzed.

The aim of the project has also changed from identifying two research problems to the creation of an AI pedagogical agent that would address the two research problems. The first research problem was to identify where and when the learner engagement drops off. The second research problem was to identify where content needs to be clearer or reemphasized. The pedagogical agent, named Morgan, would pop up at the point when engagement drops off. The pedagogical agent will provide either encouragement, explanation or a new path for the learner to follow so that the learner can complete the task. In addition, research partners will need to be identified to assist in the process of the AI creation based on the current data collected.

However, since Georgia Tech Professional Education now uses Canvas as the Learning Management platform instead of Moodle, replication of research needs to be conducted in the same course in Canvas.

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The Moderating Effects of E-learning Experience and Employment Status on Students' Satisfaction and Perceived Learning within an e-Learning Environment

Abdullahi Abubakar Yunusa
Department of Curriculum Studies and Educational Technology,
Faculty of Education & Extension Services,
Usmanu Danfodiyo University Sokoto, Nigeria &
Centre for Instructional Technology and Multimedia, Universiti Sains Malaysia, 11800 Minden, Pulau Penang, Malaysia
abdullahi.yunusa@udusok.edu.ng

Irfan Naufal Umar
Centre for Instructional Technology and Multimedia, Universiti Sains Malaysia, 11800 Minden, Pulau Penang, Malaysia
irfan@usm.my

Abstract

Students' satisfaction and perceived learning outcomes are critical determinants of the effectiveness of a learning system and provide the needed competitive edge at the end of the learning experience. While studies are bound that examined these factors within e-Learning systems in disparate contexts, there are few literatures that investigated the variability within the population based on the e-Learning experiences and the employment status of the students. Therefore, in this study, we developed an integrated model and utilized it to investigate the critical predictive factors (CPFs) that promote students' satisfaction and perceived learning outcome within an e-Learning environment in a developing context, specifically Nigeria. In addition, the study examined the moderating effects of e-Learning experience and employment status on students' satisfaction and perceived learning within the e-Learning system. 267 responses were received from a Google form shared link together with a physically administered questionnaire survey instrument and was analysed using the Partial Least Squares Structural Equation Modelling (PLS-SEM) multigroup analysis technique (MGA). From the 21 Paths evaluated, results show that e-Learning experience and the employment status of the students moderated 11 relationships within the model, thus, confirming the relevant hypotheses, while 10 hypotheses were not supported. The discernment made and the implication for theory and practice for the institutional management of the ODL system in Nigeria were discussed.

Keywords: *e-Learning, Distance Learning, Digital Technologies, Internet, Satisfaction, Perceived Learning*

Introduction

Technology and the internet have become intricately woven and intertwined into the fabrics of society, in particular, institutional managers within the educational sector have come to terms with the realities of technology as a major driver, catalyser, an accelerator and a multiplier of the opportunities within the different facets of the sector. However, these affordances are made

possible on account of the growth of the internet and internet technologies. Recognising these immense factors, institutions across the globe are investing in these technologies to multiply and scale-up access and provide opportunities for more citizens to advance their education, hone their skills, and contribute to national economic growth and development (Mtebe, 2020). In addition, the deployment of technology enhances the institutional reputation and increases its coverage, consequently attracting research interests and advancing knowledge and academic development.

These transformations in the distance education spectrum have evolved from paper based correspondence education to modern day electronic Learning (e-Learning) model(Dick, Akbulut, & Matta, 2020). Consequently, disparate pedagogical approaches have emerged, terms such as online learning, hybrid learning. blended learning, virtual learning, e-Learning have continued to dominate the education space. Recently, the Corona virus pandemic (COVID-19) challenge birthed the emergency remote learning model leading to the escalation in the application of e-Learning resources for learning (Aboagye et al., 2020).One common feature of the digital learning models is the centrality of digital technologies as the delivery medium and the eclipse of time, space, and location inhibitions. A situation Moore, (2013) described as the transactional distance which is characterized by the dialogue that happen between the learner and the instructor, or facilitator. A scenario that has significantly shifted the burden of learning on to the students. Researchers such as Moore, Dickson-Deane, & Galyen,(2011) have pointed out the inconsistencies in the conceptualizations of e-Learning.

These researchers argued that stake holders tend to conflate the diverse models in their definitions. In that respect, Tulinayo, Ssentume, and Najjuma, (2018) defined Digital Technologies as a broad range of tools, services and applications in the form of software and hardware that are used to facilitate services and activities through electronic medium. They are used for creating, storing, processing transmitting and displaying information. When deployed for educational/pedagogical purposes they are often referred to as e-Learning resources. Over the years, researchers have variously defined the concepts of e-Learning. For instance, Stefanovic, Nikolic, Drapsin et al., (2011) described e-Learning as learning via internet enabled by digital technology and it is a major phenomenon adopted by institutions to improve the teaching and learning process. In alignment, Hussein, Daoud, Alrabaiah, and Badawi, 2020); Binyamin, Rutter, and Smith, (2020) describes e-Learning as an all-encompassing concept that includes all forms of teaching and learning that occur partially or completely using digital technologies. In this study, we considered the Open and Distance Learning process at the National Open University of Nigeria (NOUN) as an e-Learning given that (90% of the delivery process is conducted online within the integrated learning management system called NOUNiLearn. (www.nounonline.net). Also, because e-Learning success can be measured through multiple perspective and tools (Serdyukov, 2020; Stefanovic et al., 2011;Authors, 2020), we considered students' satisfaction and perception of learning as appropriate measures of the NOUNiLearn system effectiveness. Customer satisfaction is a widely accepted measure of the acceptance of a product in business research and economics. In e-Learning and education by extension, it may be the reflection of the success of the learning experience. Hence, this study considers students' satisfaction and the perceptive fulfilment of their learning expectations as a plausible measure of the effectiveness of NOUNiLearn.

Many factors have been advanced as critical predictive factors of students' satisfaction with the e-Learning system; student factors, instructor factors, interaction factors, motivational factors, quality factors, learning environment, as well as the resources deployed for the learning experience

play important roles in students' satisfaction within the e-Learning system (Yunusa & Umar, 2021; Alhabeeb & Rowley, 2018)). Therefore, these factors must be considered to ensure successful learning process within the system (Stefanovic et al., 2011). The National Open University of Nigeria (NOUN) was established in the mode of the Open University UK, Allamal Iqbal Open University Pakistan and many others across the world. However, there is limited empirical evidence on students' perspectives of the effectiveness of the system measured through the lens of students' satisfaction and perceived learning based on their learning experiences. Therefore, this study is pertinent, moreover, as Serdyukov, (2020) asserted, though, e-Learning offers the benefits in terms of access, inclusiveness, and multiplying the spaces for learning, It also harbours some challenges to the students that affects them in different ways that leads to their withdrawal, dropout and poor learning motivation and outcomes (Carr, 2000 as cited in (Aboagye, Yawson, & Appiah, 2020). Serdyukov argues that the e-Learning environment tend to exert some influence on the learners cognitively, behaviourally, and learning expectations. Nonetheless, the need for career advancement, improved skills, and certification among others, has increased the support for online learning among adult citizens in different contexts (Bolliger & Halupa, 2018; Bolliger, & Martindale, 2004; Allen et al., 2016). Therefore, we considered it plausible to measure the effectiveness of the e-Learning platform from the perspectives of the learners' satisfaction with their learning experiences. The study is significant as it provides students' perspectives of the system that might help to improve critical sectors of the system, provide additional empirical grounding on the effectiveness of the e-Learning system in Nigeria and inform effective curriculum design and development within the e-Learning system in Nigerian context.

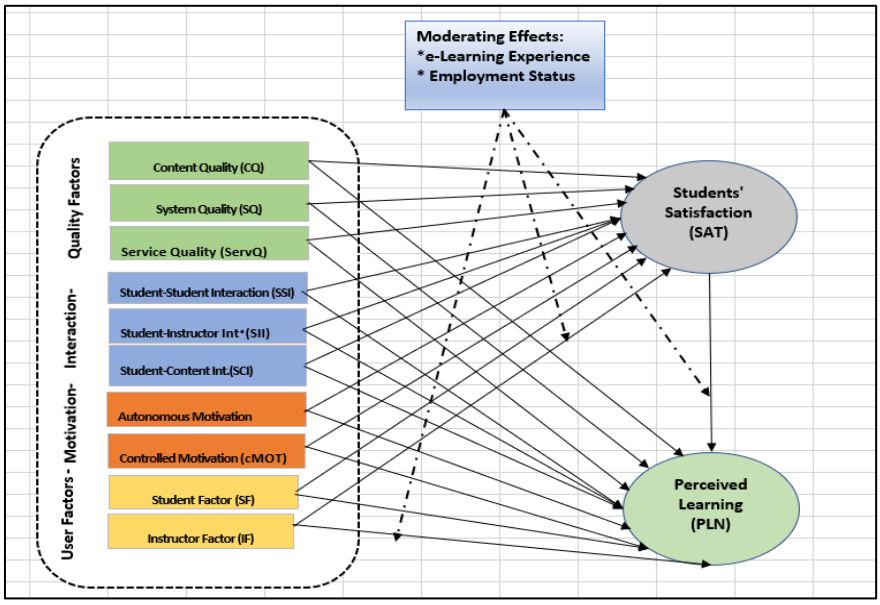

Figure 1. Conceptual Framework of the study

Hypotheses development

Based on review of literature, an integrated framework was conceived, and it comprised of the critical predictive factors (CPFs) of satisfaction and perceived learning (Yunusa & Umar, 2020). As conceptualized in Figure 1. The framework was developed from the quality factors of the DeLone & McLean Information System Success model (D&MISS) (DeLone & McLean,

2003), Theory of Transactional Distance (TTD) (M. G. Moore, 2013), Self-Determination Theory (SDT) (Deci & Ryan, 2015) and the User Characteristics factors (Ozkan & Koseler, 2009; Sun, Tsai, Finger, Chen, & Yeh, 2008) ; Sun et al., 2008). The framework was formed because a single model may not be sufficient to explain the phenomenon under investigation. Hence, since a nomological framework might lead us to the desired study outcome, it is considered plausible. Consequently, demographic variables (e-Learning experience and Employment Status were added to the fray since they improve the explanatory power within the model based on the recommendation by Venkatesh, Morris, & Davis, (2003).We draw on previous studies that adopted the use of integrated models to answer to pertinent e-learning questions and provide better understanding of various concepts such as behavioural intention and continuance intention to use of MOOCs (Zhou, 2016), examination of relationships among students self-determination, technology acceptance, and satisfaction to use MOOCs (Joo, So, & Kim, 2018), willingness to develop sport tourism (Lin, Chen, Tan, Lee, & Yang, 2018), university students level of satisfaction and readiness for e-learning (Topal, 2016), as well as measuring technology acceptance level of teachers (Koral Gümüşoğlu, 2017), studies that were predominantly in the context of developed countries.

The following hypotheses were formulated based on the research objectives.

E-learning Experience Moderating Effects

Researchers; Lu & Chiou, (2010); Yukselturk, (2009) reported conflicting outcomes in their study. While Lu & Chiou (2010) identified job status as a moderating factor in the linkage between system quality and satisfaction, Yukselturk, (2009) could not establish any significant moderating effect of age, gender, educational level and previous online experience on the students' satisfaction with online learning experience. Consequently, more research is required to better understand these phenomena, though, there are argument regarding the justification for including moderation analysis in model formation (Holland, Shore, & Cortina, 2017) . Nonetheless, we hypothesize that:

H1: (a, b, c, d, e, f, g, h, i, j): e-Learning experience moderates the effects of (CQ, SQ, SVQ, cMOT, aMOT, IF, SF, SSI, SII, SCI) on students' satisfaction (SAT) within the e-Learning environment.

H2: (a, b, c, d, e, f, g, h, i, j): e-Learning experience moderates the effects of (CQ, SQ, SVQ, cMOT, aMOT, IF, SF, SSI, SII, SCI) on students' perceived learning (PLN) within the e-Learning environment.

H3: e-Learning experience moderates the effect of students' satisfaction (SAT) with the e-Learning system on perceived learning outcome.

Employment Status Moderating Effects

Over the years, researchers have investigated the effects of demographic factors on e-Learning effectiveness in higher education at different contexts (Islam, Abdul Rahim, Liang, & Momtaz, 2011;).(Tarhini, Hone, & Liu, 2014b; Wang et al., 2009) results show that conflicts exist regarding the moderating effect factors within the system thus, warranting further research in that regard. Islam et al., 2011 reported significant moderating effects of age, program of study, and level of education on e-Learning effectiveness. Against this backdrop, we hypothesize that:

H4: (a, b, c, d, e, f, g, h, i, j): Employment Status moderates the effects of (CQ, SQ, SVQ, cMOT, aMOT, IF, SF, SSI, SII, SCI) on students' satisfaction within the e-Learning environment.

H5: (a, b, c, d, e, f, g, h, i, j): Employment Status moderates the effects of (CQ, SQ, SVQ, cMOT, aMOT, IF, SF, SSI, SII, SCI) on students' satisfaction within the e-Learning environment.

H6: e-Learning experience moderates the effect of students' satisfaction (SAT) with the e-Learning system on perceived learning outcome.

Purpose and Method

The study sought to answer the following research questions:

(i) What are the critical predictive factors of e-Learning satisfaction and perceived learning within the e-Learning environment?

(ii) How do e-Learning experience and Employment Status moderate students' satisfaction and perceived learning within the e-Learning environment?

The study adopted the quantitative research design approach (Clark & Creswell, 2015) A Google form online link was shared on the WhatsApp platforms of the target respondents and the questionnaire was physically administered to gather the data. The respondents are Bachelor of Education undergraduate students who had enrolled in the ODL e-Learning programme for at least four semesters. This category of students was targeted because they have used and garnered enough experience to report on their satisfaction and learning expectations of the system. Researchers have argued that students are better placed to define the effectiveness of the e-Learning environment because they are the target clientele and the most users of the system (Sher, 2009). The survey instrument included questions with items drawn from previous research instruments with established validity and internal consistency reliability. And based on quality factors, interaction, motivation as well as user characteristic factor items. The students are expected to respond to the five-point Likert scale statement (*ranging from 1-Strongly Disagree (SD) to Agree 5-Strongly (SA*) to reflect their perceptions with the e-Learning system predicated upon their prior learning experiences.

Findings and Discussion

Responses were gathered from 285 students whose age range between 18 to 55 years, 64% (n-171) are *male* and 36% (n-96 are *female*). Also,64.4%(n-172) are *employed* while 35.6% (n-95) are *not-employed.* Meanwhile, 85% (n-228) of the respondents have significant e-Learning experience. Consequently, 267 responses were found useable for analysis using the Partial Least Squares Structural Equation Modelling (PLS-SEM). PLS-SEM was chosen because it is widely accepted as a useful tool for investigating causal model relationships (regressions) and moderating effects. PLS-SEM is preferred for its relative advantages over first generation statistical analysis techniques especially been amenable to all kinds of data (normal and non-normal) (Ghasemy, Teeroovengadum, Becker, & Ringle, 2020; Sarstedt & Ringle, 2020). PLS-SEM can simultaneously test the plausibility of an entire collection of propositions of a causal theory, can model multiple independent variables (IVs) and multiple dependent variables (DVs)(Lowry & Gaskin, 2014).

The analysis was conducted using the SmartPLS version 3.2.8 (Ringle, Wende and Becker, 2015) after data cleaning and ensuring that basic statistical assumptions were met. As noted by Trochim, (2006) data analysis encompasses three fundamental steps viz: Data preparation, data description and Hypotheses testing. Thus, based on the recommendations by Hair, Sarstedt, & Ringle, (2019); Sarstedt, Ringle, & Hair, (2017) a two-step approach was followed to determine the convergent validity and the composite reliability indices as quality criteria, while the

discriminant validity and collinearity issues were also assessed followed by the structural model analysis to test for relationships. The results for the path coefficients and differences in terms of Employment status and e-Learning experience between the groups is presented in Tables 1 and 2.`

Table 1: Significant values for the moderating effects of e-Learning experience

Relationship	Beta value More experience -Less experience	t-value More experience -Less experience	p-value More experience vs Less experience
CQ →PLGN	0.697	3.053	0.001
CQ → SAT	-0.439	3.469	0.000
IF → PLGN	-0.284	0.970	0.167
IF →SAT	0.932	6.684	0.000
SAT → PLGN	-0.204	0.880	0.190
SCI → PLGN	0.399	2.374	0.010
SCI →SAT	0.037	0.264	0.396
SF →PLGN	0.735	4.168	0.000
SF →SAT	-0.334	2.673	0.004
SII → PLGN	0.275	1.418	0.079
SII → SAT	-0.286	2.715	0.004
SQ →PLGN	-0.563	3.241	0.001
SQ → SAT	0.366	3.492	0.000
SSI → PLGN	-0.269	1.223	0.112
SSI → SAT	-0.268	2.257	0.013
SVQ → PLGN	-0.234	0.986	0.163
SVQ → SAT	-0.038	0.320	0.375
aMOT →PLGN	-0.712	3.846	0.000
aMOT → SAT	-0.142	1.140	0.128
cMOT→PLGN	0.487	4.501	0.000
cMOT → SAT	-0.134	1.898	0.030

Key:CQ: content quality; SQ: system quality, SVQ:service quality, IF: instructor factor. SF: student factor, aMOT:autonomous motivation, cMOT: controlled motivation, SII:student-instructor interaction, SSI:student-student interaction; SCI: student-content interaction.

Table 1 shows the summary of the moderating effects (path coefficient differences) of e-Learning experience among the relationships within the model. There were significant moderating effects of e-Learning experience in 13 of the 21 linkages with six skewed towards the more experienced students thus, supporting the hypotheses in the following paths/linkages: (CQ→PLGN:β-diff=0.697,p<.005);(IF→SAT:β-diff=0.932,p<0.00);(SCI→PLGN:β-diff=0.399, p < 0.010); (SF→PLGN:β-dif= 0.0.735; p<0.00); (SQ→SAT: β-diff=0.932, p< 0.00) and (cMOT→ PLGN: β-diff = 0.487; p < 0.00). On the other hand, the moderating effects of e-Learning experience was stronger among less experienced students in the following paths (CQ→SAT: β-diff= -0.286, p= 0.004); (SF→SAT: β-diff=-0.334,p=0.004); (SSI→SAT: β-diff=-0.268,p=0.13); (SII→SAT:β-diff=-0.286,p=0.004); (SQ→PLGN:β-diff=-0.563,p=0.00); (aMOT→PLGN: β-diff=-0.712, p=0.00); (cMOT→SAT: β-diff=-0.134,p=0.34).

These results suggest that in terms of motivation more experienced students appreciate the role of controlled motivation more importantly. Also, that low experienced students placed more importance on the contents than the technology. This may be ascribed to the maturity of more experienced students and longevity of system usage. It may be deduced that the more experienced students appreciate more the roles of the instructor, the efficiency of the technology, the quality of the materials and interaction with course mates as important factors in e-Learning environments.

Additionally, results align with the assertion by Stoel and Hye Lee (2003) regarding the significance of longevity of usage to increased appreciation of ease of use and positive attitude to technology. Therefore, more attention should be given to the new users of the system to help them in actualizing their expectations of the e-Learning environment. More studies are required to better understand the role of e-Learning experience in students' satisfaction.

Table 2: Results for the significant moderating effects of employment status

Relationships	Beta value diff Employed – Not Employed	t-value Employed vs Not Employed	p-value Employed vs Not Employed
CQ →PLGN	0.320	2.217	0.014
CQ → SAT	0.139	0.735	0.232
IF → PLGN	0.259	1.196	0.117
IF →SAT	-0.145	0.432	0.333
SAT → PLGN	-0.978	5.115	0.000
SCI → PLGN	-0.025	0.158	0.437
SCI →SAT	-0.453	2.089	0.020
SF →PLGN	-0.243	1.456	0.074
SF →SAT	1.120	4.554	0.000
SII → PLGN	-0.750	2.838	0.003
SII → SAT	1.127	2.569	0.006
SQ →PLGN	-0.102	0.572	0.284
SQ → SAT	-0.532	1.968	0.026
SSI → PLGN	0.279	1.603	0.056
SSI → SAT	-0.177	0.705	0.241
SVQ → PLGN	0.052	0.303	0.381
SVQ → SAT	-0.124	0.442	0.330
aMOT →PLGN	0.481	2.538	0.006
aMOT → SAT	-0.116	0.575	0.283
cMOT→PLGN	0.260	1.870	0.032
cMOT → SAT	-0.189	0.970	0.167

Key: CQ: content quality; SQ: system quality, SVQ: service quality, IF: instructor factor. SF: student factor, aMOT: autonomous motivation, cMOT: controlled motivation, SII: student-instructor interaction, SSI: student-student interaction; SCI: student-content interaction.

From Table 2: It can be seen that there were significant moderating effects of employment status with *the employed students* recording higher path coefficients in the paths: (CQ→PLGN: β-diff= 0.32, p= 0.014); (SF→SAT: β-diff= 1.120, p< 0.000); (SII→SAT: β-diff= 1.127, p= 0.006); aMOT→PLGN: β-diff= 0.481, p= 0.006); and cMOT→PLGN: β-diff= 0.260, p= 0.032).There were also significantly negative moderating effects of employment status in the paths: (SAT→PLGN: β-diff=-0.978, p< 0.000); (SCI→SAT: β-diff=-0.453, p=0.020); (SII→PLGN: β-diff=-0.750, p= 0.003); (SQ→SAT: β-diff=-0.532, p=0.026). These results suggest that the "Not employed students" had a more significant perception of the system within those relationships. And employment students failed to moderate students' perceived quality towards e-learning

satisfaction. The findings paralleled the study by Yuselturk (2009) but conflicted that by Lu and Chiou (2010) who reported job status as a moderating factor in interface friendliness and e-learning satisfaction. Based on the findings, it may be concluded that the universality of the e-Learning environment was emphasised in the study as a system that is open to diverse form of learners. Whether experienced, in-experienced, employed, or un-employed.

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Understanding students' pre-existing computational thinking skills and its relationship with their block programming performance

Shenghua Zha, Ph.D.,
College of Education and Professional Studies, University of South Alabama, Mobile, AL 36608

Joe'l Billingsley, Ph.D.,
College of Education and Professional Studies, University of South Alabama, Mobile, AL 36608

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computational thinking, block programming, prior experience, learner analysis

Introduction

Computational thinking (CT) skills have been specified in many state standards of computer science (CS) education (*Promote computer science*, 2019). They are a set of skills utilizing abstraction, algorithmic thinking, decomposition, pattern generalization, and evaluation to solve problems (Selby & Woollard, 2013). Educators and researchers have proposed that CT is not only used in CS-related fields but also frequently applied in other areas even in our daily lives (Barr et al., 2011; Wing, 2006, 2011).

As a result, investigations have been conducted in recent years regarding CT skill development without computers. Researchers deployed non-programming activities in K-12 classrooms (Ballard & Haroldson, 2021; Lambert & Guiffre, 2009; Thomas et al., 2019). Those activities include games, simulations, picture book reading, or story creation. Results of those studies showed a significant improvement of students' CS/CT skills, especially their basic coding skills, such as the definition of variables and use of simple loops and conditionals (Ballard & Haroldson, 2021; Grover et al., 2019; Lambert & Guiffre, 2009).

These findings not only supported the efficacy of non-programming activities in improving young students' CT skills but also encouraged us to further explore young students' development of CT skills prior to coding or robotics programs.

This study was a part of the learner analysis in the design of a robotics program. In this study, we examined the CT skills of middle school students from an underrepresented minority group. Our research questions were: 1) did the students' CT skills in solving gaming problems predict their performance of block programming? 2) What other factors, such as gender and prior coding or robotics learning experiences, contributed to students' performance of block programming?

Methods

Participants

Forty-eight students from three classes at a local middle school participated in this study. A convenient sampling method was used as the participating students were from the classes where

the instructors collaborated with the authors in the robotics program. 42% were girls, and 56% were boys. 81% self-identified themselves as African Americans. 4% were Latinos and Caucasian, respectively. 67% were in Grade 8, and the rest were from Grade 7.

Instrument

We collected and analyzed data from a survey and a quiz, which were delivered at one time in a class session. The survey included questions asking students demographic information. The quiz included 16 questions from the CTt instrument validated by Román-González et al. (Román-González et al., 2016; Román-González et al., 2018). Among them, eight measured students' algorithmic thinking and pattern recognition skills in gaming problems, and 8 measured the same skills in block programming problems. Students had 40 minutes to complete the survey and quiz.

Analysis & Results

We conducted a multiple regression to identify the predictability of students' CT skills in solving non-programming problems, their prior coding and robotics learning experiences, and their gender on their CT skills in solving block programming problems.

The dependent variable was students' CT skills in solving block programming problems. It was the average of 8 quiz questions measuring CT skills in solving block programming programs. Students' CT skills in solving non-programming problems, their prior coding and robotics learning experiences, and their gender were the predictors. Among them, students' CT skills in solving non-programming problems were the average of 8 quiz questions measuring students' CT skills in solving non-programming problems. Students' prior coding and robotics experiences were dummy coded, with 1 meaning Yes and 0 meaning No. Students' gender was coded as 1 being boys and 2 being girls. Results of the descriptive statistics of these variables are shown in Table 1.

Table 1.
Descriptive Statistics

	Mean	*SD*	*N*
CT in Block Programming Problems	1.11	1.14	48
CT in Non-programming Problems	2.57	1.14	48
Prior Programming Experience	.17	.38	48
Prior Robotics Experience	.17	.38	48
Gender	.65	.48	48

Results of the multiple regression showed that students' CT skills in solving non-programming problems and their prior robotics learning experience significantly predicted and explained 44% variation of their CT skills in solving block programming problems ($F(4,43)=8.52$, $p<.01$).

$$CT_{block\text{-}programming}=.45*CT_{non\text{-}programming}+.91*Experience_{robotics}$$

We did not find a significant impact of students' prior programming experience and gender on their CT skills in solving block programming problems.

Discussions

Results of our study showed a significant relationship between students' CT skills in solving gaming and block programming problems. From the instructional design perspective, it supports the use of non-programming methods to improve students' CT skills. At the same time, it suggests that students may have developed some CT skills prior to any coding or robotics programs. Those skills may be developed from their interactions with real-world problems or in prior learning experiences. Therefore, it will benefit students' understanding of coding if we activate their prior knowledge and skills and use the real work examples or their prior knowledge to explain the coding algorithms.

We also found that students' prior robotics learning experience had a significant impact on their CT skills in solving block-programming experiences, but their prior programming learning experience did not. We think it may be because robotics provides tangible and visual aids for students at young ages to develop an abstract understanding of CT skills. However, studies with a large sample size are needed to verify this finding.

African American students have been reported as underrepresented in secondary CS education (Code.org, 2020). In addition, the gender disparity within the underrepresented minority group was found to aggravate this inequity (*Current perspectives and continuing challenges in cs education for u.S. K-12 schools 2020 report*, 2020). Results of our post-hoc analysis did not show a gender difference in students' CT skills in solving gaming problems when their prior robotics learning experience was taken into account. It could be because only boys were found to have prior robotics experiences. This finding endorses the results in the national report. In addition, it underscores the necessity to broaden participation for underrepresented minority students, especially the female students from that group. We suggest future studies consider the impact of students' prior experiences when examining the gender difference.

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Analysis of Data-based Learner Characteristics – Taking Fourth-grade Students in a Certain School as an Example

Yumeng Zhou
Department of Education Information Technology, East China Normal University
Shanghai, China
51194108025@stu.ecnu.edu.cn

Abstract: With the development of education information, a new round of scientific and technological changes and challenges have set new goals for talent cultivation and education innovation and put forward new requirements for the analysis of learners' characteristics. The use of user portrait technology in education can help teachers to keep pace with the development of learners and provides a way to promote the future development of students' learning. And data collected by electronic schoolbags in real time make data-based analysis feasible. This paper mainly uses data-based learning analysis method to analyze and mine the data of a fourth-grade elementary school. Firstly, the pre-processed data is descriptively tested to see if it conforms to the normal distribution. After that, the student's grades are standardized and clustered. Secondly, the processed data is used to map the student's comprehensive situation radar map. Based on the results of radar map and cluster analysis, targeted suggestions are put forward for learning and teaching. This study provides a reference model and a new thinking dimension for data-based learner feature analysis and the research results have theoretical value and practical significance.
Keywords: Analysis of learner characteristics; User portrait; Electronic schoolbag

1 Introduction

Since the 21st century, education information reform has been unanimously recognized in the education field. Subsequently, the "Bring Your Own Device (BYOD)" campaign, which allows every student to obtain and use a mobile device, began to be promoted (Liu Bin et al., 2016). Through these portable mobile devices, students can read various electronic textbooks and online courses and other resources needed for learning, which is conducive to the development of one-to-one digital learning. The electronic schoolbag is a new technological product born with the development of science and technology since the 21st century. E-schoolbags have been experimenting in the field of foreign education a long time ago. However, for various reasons, the development of e-schoolbags in China has not kept pace with foreign countries and started late (Tong Hui et al., 2016). It was not until 2013 that e-schoolbags finally started to be tested in China (Wang Yujie, 2018). At present, due to the characteristics of the e-schoolbag itself, its scope of application is not wide. E-bookbag trials have been conducted almost only in schools and areas with better educational resources and higher quality of teaching. The electronic schoolbag uses an electronic terminal to integrate the students' books. It can change the traditional classroom format, not only the carrier of teaching, but also the teaching model to a certain extent (Fan Minsheng et al., 2017). Electronic schoolbags are an important means of communicating traditional school education and education informatization. It creates conditions for the collection of learner data, which in turn provides strong support for the development of data-based learning analysis (Zheng Liqing, 2014).

This research is mainly devoted to the analysis of learner characteristics based on data, and at the same time, it provides a reference model and some new thinking dimensions for the analysis

of learner characteristics based on data in the background of information technology. Therefore, this research uses a series of data from e-schoolbags to analyze the characteristics of learners and make suggestions.

2 Literature Review

2.1 Learning Analysis

As an emerging field of learning analysis, its development is closely related to information technology and educational intelligence. Learning analysis uses data and models to predict the future state of learners and discover potential problems through analysis (Liu Qingtang et al., 2017). Learning analysis reports can help to better understand learners' learning styles, learning habits, and cognitive structure, and other information, so it helps teachers to prescribe the right medicine and develop personalized learning plans for students (He Kekang, 2016). In addition, through learning analysis, a comprehensive observation and recording of the entire learning process of learners can be used to grasp the learning situation of students in real time, which can help teachers make timely adjustments to their own teaching plans and teaching strategies. Nowadays, to measure, collect and analyze learners and learning environment, and get corresponding reports, and then use these reports to optimize the learning process of learners and the learning environment in which they are located. It is a technology for learning analysis. Accepted definition (Wu Yonghe et al., 2013; Siemens, 2011).

Learning analysis has attracted the attention of domestic scholars since the Horizon Report released in 2011. Gu Xiaoqing and others define learning analysis as: using different analysis methods and data models to explain the data related to learner information, and then explore the learning process and laws of learners; or interpret learners' learning performance based on data and provide them with corresponding feedback Thereby promoting more effective learning (Gu Xiaoqing et al., 2012). Learning analysis is based on the massive omni-directional data generated by students in the learning process to carry out data analysis and mining, using visual means to present the results of data analysis and mining, and then teachers and teaching administrators can carry out data analysis and mining based on the obtained predictive model The prediction of students' various learning behaviors. In this way, it is helpful to find risk learners and intervene in time. In addition, it can also push personalized learning resources and design personalized learning paths for students. Therefore, learning analysis can be regarded as achieving teaching students in accordance with their aptitude. Technical support for the purpose.

2.2 Learner Characteristics Analysis

The new round of technological changes and challenges has put forward new goals for talent training and educational innovation and has also put forward new requirements for the analysis of learner characteristics. "Taking the learner as the center" is a major purpose of the new situation classroom under the guidance of current constructivism (Yu Jiajun, 2015). Compared with the traditional classroom, the role of teacher and student are changed, so that the learner can change from a passive position to an active position and become a meaning builder. At the same time, teachers have also changed their previous roles, becoming instructors and facilitators of learning. Therefore, students are extremely important for the ability to clearly understand their own original cognitive structure and to actively construct the meaning of relevant knowledge based on their own experience. Learner analysis has become an important part of it. Based on this background, many scholars and researchers have conducted in-depth explorations on learning analysis in the new educational information environment (Xu Qi et al., 2021; Chen Changsheng et al., 2020; Sabine Seufert et al., 2019). With the development of the education field, the content

and dimensions of learning analysis are also constantly changing. On online learning platforms (such as the MOOC platform), thanks to the comprehensiveness and convenience of platform data acquisition, many meaningful research results have emerged, which has promoted the development of these platforms. However, due to the inconvenience of the acquisition and collection of offline course data, there are still problems in applying similar learning analysis techniques to traditional classrooms (Huang Qin, 2017).

Data mining on the acquired education data through learning analysis technology can provide strong support for the development of education and teaching. Learning analysis can cover the entire process from diagnostic evaluation to formative evaluation to summative evaluation, providing powerful support for schools, teachers, students, and parents to learn about teaching, learning, and results, thereby providing guidance for promoting learning and improving performance. Therefore, how to use the existing experience in traditional school education to carry out the analysis of learning that meets the new requirements of today, to promote the development of classroom education, is a problem worthy of consideration and exploration.

2.3 Learner Portrait

As far as the current situation is concerned, at the practical level of the education field, the big data user profile technology has not been tested in the true sense (Xu Yan, 2017). Learner portrait is the multi-dimensional quantification of learner's internal or external characteristics. It is an abstract student model obtained based on data analysis and mining. Learner portraits outline the image of learners through the modeling of related data, restore students' various characteristics, motivation levels and other potential attributes, and then understand learners' behavioral tendencies and needs, and derive learning laws hidden in many learners. Carrying out the analysis of learner characteristics in different dimensions for different learning scenarios can improve the design of learning platform, improve the learning recommendation system and teaching strategies (Xiao Jun et at., 2019). Most of the foreign researchers carry out research by dividing the roles of learners by certain characteristics, which include learners' learning motivation, cognitive level, and learning attitude. Scholars such as Wataru Takahashi provide corresponding services to different learners based on the motivation composition, self-efficacy cycle, and service incentive effects of different roles. Takahashi et al., 2014). Foreign scholars have also conducted in-depth research on how to build learner portraits. The goal of establishing a learner's profile is to focus on the implementation of learning needs, motivations, preferences, etc., and present the main characteristics of learners. Scholars such as Debbie Holley divide students into different risk levels, predict the learners' use of risk models, and then implement corresponding interventions. Therefore, accurately describing learning ability, providing guidance for teachers to carry out teaching, and promoting the improvement of professional skills are the important values of establishing learner profile.

With the continuous in-depth development of the concept of learner portraits, domestic scholars have gradually begun corresponding research. Through research, some scholars believe that the establishment of learner profile in a ubiquitous learning environment is an important part of the design of MOOC resources, and the evaluation of learning effects can also be achieved through learner profile (Wang Xiaofang et al., 2019). The significance of learner profile technology in personalized teaching has also been confirmed by many empirical studies conducted by domestic scholars based on experiments (Chen Haijian et al., 2017; Tang Yewei et al., 2019).

In summary, as the application of user portrait technology in education, learner portrait technology plays an important role. The learner profile technology can not only make precise positioning according to the different characteristics of learners, but also can be further used in the

optimization link of teaching design to provide targeted support for learning, to better serve personalized learning. However, at present, the research on learner profile technology still focuses on how to build models and how to apply them, and there has not been an overall description of the process of learner profile building.

3 Method

3.1 Research Path

In this research, EXCEL, RStudio, and SPSS are used to model with learner characteristics analysis method based on data. First, the obtained student performance data is standardized, and then various indicators are used for cluster analysis. Then, the standardized student performance is non-linearly transformed, and a radar chart is drawn based on the standardized student performance, and the radar chart is used to perform a single Analysis of student performance to promote the overall development of students.

3.2 Data Sources

A certain elementary school aims to promote the application of information technology in education and has carried out a long period of in-depth exploration in the use of electronic schoolbags to carry out teaching. The "electronic schoolbag" used by the fourth-grade students in this elementary school has many special functions, which can enhance classroom interaction and produce better teaching results. The emergence of electronic schoolbags has created conditions for the development of data-based learning analysis in school education, and the use of electronic schoolbags in the fourth grade of a primary school is providing a good case study for data-based learning analysis in school education. Thus, this research started. The daily teaching activities in the fourth grade of a primary school are basically carried out using electronic schoolbags. Through the electronic schoolbag, teachers use the online course platform to present teaching content, collect teaching materials, interact with students, publish assignments, and test information, and carry out evaluation activities; students use the online course platform to conduct group interactive discussions, communicate with teachers, and obtain teaching Activities such as content, completion of homework and quizzes. In this process, a large amount of student data was generated. These data include student PAD usage, classroom interaction, evaluation activities, evaluation results statistics, knowledge mastery, statistics on the number of teacher lectures, etc. Among them, some data about the evaluation activities are incompletely recorded, students' knowledge mastery in some time periods, and individual student data are missing.

The data selected in this study comes from the data in an electronic schoolbag used by 29 fourth-grade students in a primary school. The daily teaching tasks of this elementary school are basically carried out through electronic schoolbags. It can be considered that the acquired electronic schoolbag data is a good and comprehensive record of the situation of the fourth-grade students in a certain elementary school.

3.3 Data Processing

3.3.1 Standard Score

The standard score is a relative status measure, which is derived based on the original score. The standard score can represent the relative position of the original score in all the scores in which it is located. The standard score is based on the standard deviation of a group of scores, and the average of the number of components is used as a reference. It can show that the original score is several standard deviations away from the overall average in the whole, and then it reflects the

relative position of this original score in the overall data. Compared with the original score, the standard score can more intuitively reflect the meaning of the obtained data. The standard score can reflect the position of the student in the overall. As a result, the same standard score can still be regarded as equivalent even if the test is different. This also provides a method for visually comparing scores in different test contexts. From this, after converting the learner's raw scores into standard scores, it will be more comparable, especially in different times, different subjects, and different types of tests. It will be more reasonable and fairer to use standardized student scores in learner analysis.

3.3.2 Cluster Analysis

Cluster analysis is a process of classifying and combining individual abstract individuals in a whole and combining individuals with similar characteristics to form classes. Cluster analysis is an important analysis method. The clustering effect depends on two factors: the method of measuring the distance and the clustering algorithm. K-means clustering algorithm is a commonly used method of clustering analysis. Its approach can be expressed as selecting K initial centroids at the beginning. The so-called centroid is the average vector of all observations in a class. The initial centroid can be selected randomly, each centroid is a class, then each observation is assigned to the centroid closest to it, and a new class is formed with the centroid, and finally the centroid of each class is recalculated and repeated until the centroid does not occur. When changing or reaching the maximum number of iterations. This research mainly uses K-means clustering algorithm to analyze student data.

3.3.3 Non-linear transformation

The student's standard score z obtained after conversion is a standard normal distribution N(1, 0). In order to facilitate the use of the obtained standard scores in subsequent analysis, non-linear conversion processing is performed on them.

The nonlinear conversion formula used is $z' = \frac{1}{\pi}\tan^{-1} z + 0.5$.

The transformation has the following characteristics:

(1) Convert the infinite interval from negative infinity to positive infinity into a finite interval from 0 to 1;

(2) Convert the original average value of the standard score (z) from 0 to an average value of 0.5;

(3) The function obtained after transformation has good linearity near the average value, and the more it deviates from the average value, the stronger its compressibility.

3.3.4 Radar chart

The radar chart is a graphical method of displaying multivariate data in the form of a two-dimensional chart of three or more variables on an axis starting from the same point. The radar chart is composed of a series of equidistant concentric circles. Each of the concentric circles corresponds to a different value, the closer to the center of the circle, the smaller the value, and the greater the deviation from the center of the circle, the larger the value. The evaluation index of the radar chart is represented by multiple axes drawn from the center of the circle. The value corresponding to each index obtained is processed and marked on the index axis according to a certain ratio, and then the marked points obtained by these marks are aligned. If you are connected to each other, you can get a radar chart that reflects each evaluation index of the sampled book.Radar chart plays a very good role in both qualitative analysis and quantitative analysis.

4 Results

4.1 Overall Characteristic of Learners

Use SPSS to explore the PAD use time and reading time in the obtained student data, and judge whether it obeys the normal distribution. The results are shown in Table 1. The absolute values of the skewness coefficient and kurtosis coefficient of the two indicators are both less than 1, which can be regarded as approximately obeying a normal distribution.

Table 1. Statistical results of PAD use time and Reading time

		Statistics		Standard Error	
		PAD use time	Reading time	PAD use time	Reading time
Mean		1157.497	39.735	131.4139	6.2917
95% confidence interval of the mean	Lower limit	889.114	26.886		
	Upper limit	1425.880	52.585		
5% trimmed mean		1109.367	37.654		
Median		827.000	28.000		
Variance		535358.163	1227.140		
Standard deviation		731.6817	35.0306		
Minimum		340.0	2.4		
Maximum		2889.7	115.6		
Scope		2549.7	113.2		
Interquartile range		1061.0	59.5		
Skewness		.894	.904	.421	.421
Kurtosis		-.156	-.478	.821	.821

After sorting out the obtained student's original scores, select the entire class of students in a certain test, and standardize the student scores in the following way.

(1) Obtain the scores of n students in the test in order of x_1, x_2...x_n, calculate the average score of the whole class of students who participated in the test μ: $\mu = \frac{\sum_{i=0}^{n} x_i}{n}$;

(2) Calculate the standard deviation σ of the obtained scores of n students in the test: $\sigma = \sqrt{\frac{\sum_{1}^{n}(x_i-\mu)^2}{n}}$;

(3) According to the standard score conversion formula, the original scores obtained by each student in the test are converted into standard scores for easy comparison by calculation. The formula is $z = \frac{x-\mu}{\sigma}$.

Some of the final processing results are shown in Table 2.

Table 2. Standardization

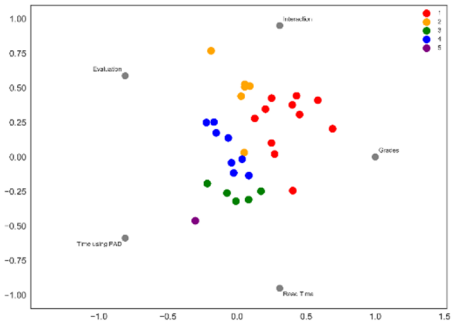
Student	Chinese	Math	English
Chen	0.104	0.482	-0.009
Dai	0.297	-0.184	-0.460
Du	0.406	0.251	0.298
Feng1	-0.445	0.372	0.138
Zhang3	0.288	0.149	0.298

Standardize students' classroom performance, teacher evaluation, pad use time, and reading time data. Select five indicators: performance indicators, evaluation indicators, interaction indicators, PAD use time, and reading time, and use SPSS to perform cluster analysis. It is divided into 5 categories, Table 3 shows the cluster analysis results.

Table 3. Cluster center

	Cluster				
	1	**2**	**3**	**4**	**5**
performance	.1212	-.1421	-.0464	.1117	-.2021
interaction	-.0923	.0337	-.1015	.1630	-.4146
evaluation	-.1005	.1645	-.1369	.1143	-.4125
PAD use time	-.2390	-.2416	.1967	.2334	.2457
reading time	-.1174	-.1465	.2163	-.0561	-.1798

RadViz radar chart can complete multi-dimensional data visualization tasks and is suitable for visualization of cluster analysis results. It is based on the basic spring pressure minimization algorithm often used in complex network analysis. The spring algorithm puts a series of nodes in the same plane, and then assumes that each data set uses a spring to connect to each node. Therefore, these nodes will move due to the existence of springs and stop when all the elastic potential energy of the entire system reaches a minimum. In the RadViz radar chart, different



colors are used to identify different classes. Figure 1 shows the drawing result.

Figure1. RadViz radar chart

The first category of cluster analysis results contains 11 students. These 11 students have good performance in performance indicators, but most of them do not perform well in classroom interaction, teacher evaluation, PAD use time and reading time indicators. Through analysis, we can clearly know that they are all able to achieve good results, but they do not tend to use PAD as a learning tool and prefer traditional book learning, nor do they like to interact with teachers in the classroom. From a long-term perspective, although such students can better complete their academic tasks through independent learning, they should still interact and communicate more with teachers, to help them discover new problems in their communication with teachers. At the same time, even if such students use less e-bookbags, they can still achieve better results. Teachers can still guide these students to use modern tools to help them learn, so that students can realize the power of the new learning tool of e-bookbags. The convenience provided for their study.

The second category of cluster analysis results includes 6 students. These 6 students have good performance in classroom interaction and teacher evaluation indicators, but most of them do not perform well in performance indicators, PAD use time and reading time indicators. This shows that although they actively participate in the interaction in the classroom, they can also get good evaluations from the teachers in the classroom, but they still cannot achieve satisfactory results. This kind of students are also more common in the classroom. Although they are active in the classroom, they may not get a good grade due to inappropriate learning methods and methods. Therefore, helping such students find a learning method that suits them is one of the key points to improve their academic performance. In addition, teachers can also consider starting from the use of PAD and consider whether these students are unable to achieve the expected results compared with other students, whether it is because they did not maximize the help effect of e-schoolbags on learning. Correct guidance to improve student performance.

The third category of cluster analysis results includes 5 students. These 5 students have outstanding performance in PAD use time and reading time indicators, but most of their performance indicators, classroom interaction indicators and teacher evaluation indicators are not optimistic. For such students, it should be considered whether they have not properly played the role of PAD, an e-schoolbag. When these students use e-schoolbags, they are likely to use it as an entertainment tool and fail to achieve the purpose of e-schoolbags to help and promote learning. These students should be guided in a timely manner, and they should be guided to use e-schoolbags to help their learning, instead of using them as a novel pastime and play tool. The real significance of introducing e-schoolbags is to use the value of e-schoolbags.

The fourth category of cluster analysis results contains 8 students, these 8 students have a good performance in other aspects except for the lower PAD reading time indicator. This shows that these 8 students can better promote their own learning through the interaction with the teacher in the classroom, can also get a better evaluation from the teacher, and can also use the electronic schoolbag to complete the learning task better. In addition, these 8 students can consider using e-bookbags to read more, study textbooks, content outside the classroom, enrich their knowledge content, and achieve better performance.

The fifth category of cluster analysis results includes 1 student. This student has outstanding performance on the PAD usage time indicator, but the performance on other indicators is not optimistic. This student is like the 5 students in the third category, and it should be determined in a timely manner whether he has correctly played the role of the e-schoolbag and actively guided.

From the above analysis, different students have different attitudes and situations towards learning with electronic schoolbags. However, it is not difficult to find from the results that the current students' acceptance and use of e-schoolbags need to be improved, and e-schoolbags still do not fully exert their value in helping to learn to a certain extent.

Through cluster analysis, 31 students are divided into 5 categories according to the five dimensions of performance indicators, evaluation indicators, interaction indicators, PAD usage indicators, and PAD reading time indicators, which helps to intuitively and clearly grasp the various Dimensional performance, and promptly discover possible problems in the learning process of students, so as to help teachers to carry out personalized teaching and prescribe the right medicine, so as to guide students to better aspects and promote the overall development of students. In addition, clustering analysis based on data can not only improve the efficiency of teachers in understanding the situation of students, but also more scientifically obtain the situation of students from the observation and feeling of teachers in traditional classroom teaching and has a good guidance for the development of teaching. significance.

4.2 Individual Characteristic of Learners

Table 4 shows some of the processing result after non-linear transformation.

Table 4. Processing result after non-linear transformation

Student	Chinese	Math	English
Chen	0.533	0.643	0.497
Dai	0.592	0.442	0.363
Du	0.623	0.578	0.592
Feng1	0.367	0.613	0.544
Dai	0.589	0.547	0.592

Do the same processing with the obtained data of student classroom performance, teacher evaluation, pad use time, and reading time, and select indicators Chinese score, Chinese evaluation, Chinese interaction, math score, math evaluation, math interaction, English score, English evaluation, English interaction, PAD use time, reading time 11 indicators, use RStudio to draw a radar chart.

When drawing, convert the 11 selected indicators into 11 corresponding dimensions in the radar chart. According to the results of data processing, the more the indicator point deviates from the central origin, the better the student's performance on the indicator. From the perspective of the area of the closed figure enclosed by each indicator point of the radar chart, if the area of the closed figure is larger, the overall situation of the students is better.

4.2.1 Case Study 1

Figure 2 is a radar chart of Zhang's comprehensive situation. From the figure, we can see that Zhang's mathematics performance indicators, mathematics evaluation indicators, English performance indicators, English interaction indicators, and PAD use time indicators are all close to the maximum value of the class. Reading time indicators, language interaction indicators, and English evaluation indicators It is higher than the average of the whole class, the Chinese performance index and the Chinese evaluation index are close to the average of the whole class, and the mathematics interaction index is lower than the average of the whole class.

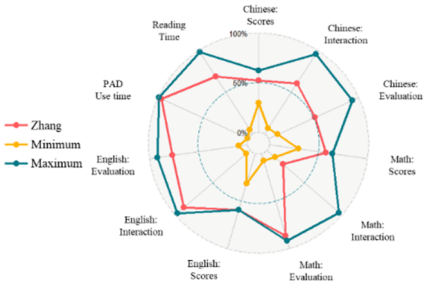


Figure2. RadViz radar chart of Zhang's comprehensive situation

(1) Teaching interaction. By observing the three interactive indicators of Zhang's Chinese, Mathematics, and English, we can find that Zhang can interact well with teachers in Chinese and English classes, but he did not interact with teachers to a similar degree in math class. This shows that in terms of teaching interaction, Zhang's situation is better, but he still needs to pay attention to his interaction in the mathematics class and find the reasons for his low mathematics interaction indicators, such as the tendency to teaching methods.

(2) Technical application. From the two technical application indicators of Zhang (PAD use time and reading situation), we can find that Zhang's PAD use time indicator is close to the highest value of the class, and his reading time indicator is also higher than the average of the class. This shows that Student Zhang can use the electronic schoolbag to study well and complete the tasks assigned by the teacher.

(3) Subject analysis. From the radar chart of Zhang's comprehensive situation, we can find that Zhang's English scores and math scores are close to the highest value in the class, indicating that Zhang has a good performance in these two subjects. In contrast, Zhang's Chinese performance is a bit weak, and his Chinese performance indicators are only close to the average Chinese performance of the whole class. As a Chinese teacher, he should pay more attention to its internal reasons, such as whether the learning method is inappropriate, the learner Zhang himself can also improve his language performance through self-reflection.

(4) Teacher evaluation. Among the three teacher evaluation indicators of Zhang, the mathematics evaluation index tends to be the highest in the class, and the English evaluation index is also higher than the average of the class, indicating that Zhang can be highly recognized by the teachers in these two subjects. However, Zhang's language evaluation index is only near the average of the class. Based on the analysis of Zhang's language performance indicators and language interaction indicators above, there is still a lot of room for improvement in Zhang's performance in language subjects.

4.2.2 Case Study 2

Figure 3 is a radar chart of Teng's comprehensive situation. From the radar chart, we can understand that Teng's PAD usage time and English performance indicators tend to be the highest in the class. In addition, Teng's Chinese performance indicators, language interaction indicators, language evaluation indicators, and mathematics scores the indicators, mathematical interaction indicators, mathematics evaluation indicators, English interaction indicators, English evaluation indicators and PAD reading time indicators all reach the average of the class or even tend to the lowest value of the class.

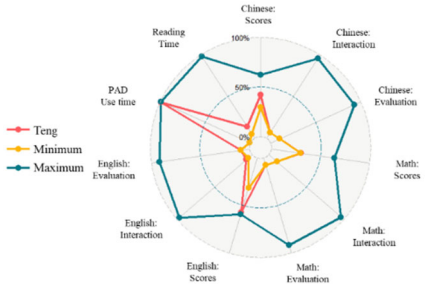


Figure3. RadViz radar chart of Teng's comprehensive situation

(1) Teaching interaction. Observing and analyzing the interactive indicators of Teng's three subjects, it can be found that these three interactive indicators of Teng are close to the lowest value of the whole class. From this we can infer that student Teng does not like to participate in learning by interacting with teachers in class. In this regard, teachers may consider guiding Teng. When considering Teng, it is for reasons of character to guide him to participate more actively in the classroom.

(2) Technical application. From the use of Teng's PAD and reading time indicators, we can find that Teng's PAD is used more frequently, and it is understood that most of Teng's other indicators are basically the lowest in the class, indicating that Teng Although students often use the electronic schoolbag as a tool, they may not give full play to the value and function of the electronic schoolbag. Based on this problem, the teacher should provide timely guidance to achieve the purpose of the electronic schoolbag to promote learning.

(3) Subject analysis. Observing Teng's Chinese, math, and English performance indicators, we can find that, except for the English performance indicators tending to the highest value of the class, the other two indicators are close to the lowest value of the class. This shows that Teng can achieve good results in English subjects, but his performance in Chinese and mathematics subjects is not good. This may be due to Teng's preference for English subjects. In this regard, teachers should start from the perspective of the content of each subject to help Teng understand the meaning of each subject to himself, to stimulate Teng's inner motivation for learning other subjects and promote the overall development of his various subjects.

(4) Teacher evaluation. Analyzing the teacher evaluation indicators of Teng in the three subjects of Chinese, mathematics, and English, we can find that Teng has not been able to get a good evaluation of the teachers in these subjects. Comparing and analyzing Teng's teaching interaction indicators and subject performance indicators, we found that they are almost corresponding. Therefore, teachers need to consider whether this is caused by Teng's learning interest or lack of learning motivation. After investigating and clarifying the reasons, they will prescribe the right medicine to help Teng become a better learner.

4.2.3 Comparative Analysis of Two Cases

By observing the radar chart of the two students, we can also observe the overall situation of the students through the area of the closed figure, that is, the larger the area of the closed figure, the better the overall situation of the students. Comparing the radar charts of the two students, we can easily find that the two students performed similarly on the English performance indicators and the PAD usage time indicator.

Judging from the three performance indicators alone, Zhang's performance in each subject has achieved a more balanced development, while Teng's performance in Chinese and mathematics is still very lacking in addition to English. This is easily reminiscent of the law of short boards. The amount of water that a wooden barrel can hold depends on the shortest wooden board of the wooden barrel, not the longest wooden board of the wooden barrel. Each of us is like a wooden barrel, with its own length and shortness. The longer plank can naturally help us to have some outstanding performance, but in the end our development will be largely determined by the shortest plank, so We should work hard to make up for the shortcomings. As a student, you should also achieve a balanced development of all subjects to promote your own outstanding development. Through the radar chart, students can clearly and intuitively find their shortcomings and try to make up for them.

5 Discussion

By drawing and analyzing the radar chart of the overall situation of students, it is helpful for teachers to grasp the situation of all students from the overall situation and formulate teaching strategies in the general direction. Analyzing the radar chart of a single student will help teachers better carry out personalized teaching, understand the strengths and weaknesses of students, and prescribe the right medicine to promote the all-round development of students. By observing their own data analysis radar chart, students can intuitively understand their own development in various aspects, more immediately understand their own strengths and deficiencies, guide students to learn to check for missing vacancies, and promote students to form a self-reflection, self-promotion, and self-improvement Virtuous circle.

Using the large amount of student data generated in real time during the use of the electronic schoolbag to perform corresponding learning analysis and generate student characteristic analysis is of broad significance for the development of further teaching and the progress of student learning. From a practical point of view, the analysis of learner characteristics based on data has the following significance. First, for students, obtaining learner characteristics analysis based on data analysis will help students to understand their real-time strengths and weaknesses more intuitively in time, forming a virtuous circle of self-reflection and self-promotion. Second, as far as teachers are concerned, obtaining real-time characteristics analysis results of students can help teachers better meet the needs of providing personalized teaching, grasp the strengths and weaknesses of students, and then set personalized development goals to guide students toward complete and comprehensive development. Third, for parents, compared to

simply knowing the learning results of students through test scores, feature analysis based on student learning data can provide parents with a measure of measurement. From a theoretical point of view, this research can provide a reference model for data-based learner characteristics analysis under the background of information technology. This research involves the use of a series of data including statistics on students' classroom performance, statistics on the mastery of students' knowledge points, statistics on the use of students' electronic schoolbags, statistics on student performance trends, completion time and completion statistics of student homework and tests, etc., to analyze and generate a series of data. Series learner characteristics. This data-based learner characteristic analysis mode can provide a reference for the development of learning analysis, and it also provides some new thinking dimensions about learner characteristic analysis.

There are still shortcomings in this research. Due to the large and complex data obtained, there is not much data left after actual screening, especially the data of some individual students have serious lacks, and some subjects and knowledge points cannot be determined, so students cannot be determined. The individual performance in each period is compared longitudinally. In addition, the originally obtained student performance data is not only Chinese, mathematics, and English, but also student science and other subjects. However, due to the small number of these subjects and the large time interval, they are not suitable for analysis. Therefore, this study only analyzed the three subjects of Chinese, Mathematics, and English.

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