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Technology Used to Support Learning in Groups

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Abstract: Across disciplines, researchers recognize that working together in a small group can be a challenging learning activity, particularly in an online course where group members meet remotely. This 2-year, design-based research study focused on improving group work in both online and blended sections of an undergraduate course for pre-service teachers. Surveys were completed by instructors ($N = 15$) and students ($N = 361$) at three different junctures during the course to learn about how technologies were used by students and instructors to support group work. Interviews were also conducted at the end of the term to gather in-depth descriptions about the types of technologies and how they were used by students and instructors to support group work. Findings indicated that students and instructors selected a combination of technologies, including institutionally supported and mainstream applications such as shared workspaces to coordinate, track, and monitor group progress. Students and instructors also described using communication technologies to manage group challenges related to scheduling, communicating, and integrating tasks into the project. Findings contribute to our understanding about how technologies were used to support process and product when working on a group assignment.

Keywords: technology-supported, online, group work, group assignment, social interdependence, teacher education

Résumé: Dans toutes les disciplines, les chercheurs reconnaissent que travailler ensemble en petit groupe peut être une activité d'apprentissage stimulante, en

particulier dans un cours en ligne où les membres du groupe se rencontrent à distance. Cette étude de recherche de deux ans basée sur la conception s'est concentrée sur l'amélioration du travail en groupe dans les sections en ligne et mixtes d'un cours de premier cycle pour les enseignants en formation. Des sondages ont été complétés par des instructeurs (N = 15) et des étudiants (N = 361) à trois moments différents pendant le cours pour apprendre comment les technologies étaient utilisées par les étudiants et les instructeurs pour soutenir le travail de groupe. Des entrevues ont également été menées à la fin du trimestre afin de recueillir des descriptions détaillées sur les types de technologies et la façon dont les technologies étaient utilisées par les étudiants et les instructeurs pour soutenir le travail de groupe. Les résultats ont indiqué que les étudiants et les enseignants ont choisi une combinaison de technologies, y compris des applications soutenues par l'établissement et des applications grand public, y compris des espaces de travail partagés pour coordonner, suivre et surveiller les progrès du groupe. Les étudiants et les instructeurs ont également décrit l'utilisation des technologies de communication pour gérer les défis de groupe liés à la planification, à la communication et à l'intégration des tâches dans le projet. Les résultats contribuent à notre compréhension de la façon dont les technologies ont été utilisées pour soutenir les processus et les produits lorsque nous réalisons un travail en groupe.

Mots-clés: soutenu par la technologie, en ligne, travail de groupe, affectation de groupe, interdépendance sociale, formation des enseignants

Introduction

Learning together in a small group is an authentic, yet challenging learning activity in either an on-campus course when there is opportunity to meet face-to-face with group members, or an online course when group members can only meet remotely (Brame & Biel, 2015). Considerable attention has been given to improving collaborative learning techniques in post-secondary classrooms on-campus (Barkley et al., 2014; Kristiansen et al., 2019), and research related to online group work is beginning to emerge (Hammond, 2017; LaBeouf et al., 2016; Lowes, 2014). Hammond (2017) notes the opportunities for technology to support students when learning in a group. Post-secondary instructors are interested in effective strategies that promote student-to-student interdependence (Clarke & Blissenden, 2013; Johnson et al., 2014), and with the recent global pandemic, teachers worldwide were required to rapidly design learning in online spaces, including activities involving learning in small groups.

Working with colleagues and learning together in a group is a professional skill and required competency for teachers (Alberta Education, 2018). Teacher professional collaboration is a critical skill linked to increased student achievement in the classes of teachers who engage in professional collaboration, and increased job performance and satisfaction (Hargreaves, 2019; OECD, 2018; Ronfeldt et al., 2015). Aspiring teachers need opportunities to experience learning in groups and develop this professional skill during their pre-service training. Technology can support group work (Gronseth & Hebert, 2019); however, more research is needed to understand how technologies are used by instructors and students in post-secondary courses to do so (Alqurashi, 2019; Kleinsasser & Hong, 2016; Roseth et al., 2011; Thom, 2020).

In this article, the authors describe findings related to the selection and use of technologies by students and instructors for a group work assignment in online and

blended (on-campus combined with online) sections of a required undergraduate course for pre-service teachers. The authors of this paper conducted the research and taught sections of the course. One author was also the course coordinator and was responsible for designing the learning activities in the syllabus, including the group assignment used for all sections of the course. The findings resulted from a larger design-based study that was focused on improving the design of the group assignment. A component of this 2-year study was to identify how technologies were used to support students when learning in a group and working together to complete a group assignment.

Literature Review

In teacher education programs, instructors often assign group work and require students to complete a group assignment with peers. Group assignments can take short periods of time and can be completed during one class (Koh & Hill, 2009; Thom, 2020). They can also take longer periods and require group members to work together for several weeks to complete them (Brown et al., 2018; Koh & Hill, 2009). Instructors can provide time during the course for group members to work together, or they may require groups to meet outside of the scheduled class time (Brown et al., 2018; Thomas & Brown, 2017). There has been extensive research on group work (Barkley et al., 2014) and many different forms of group assignments, so it is not surprising there are various terms used in the literature to describe learning in groups (Boyle et al., 2019; Clark & Blissenden, 2013; Johnson et al., 2014, Johnson & Johnson, 2018). In this paper, the authors describe a group assignment that took place for the duration of an 8-week undergraduate course in education, and the design of the assignment was based on both cooperative and collaborative learning approaches. Students were provided with some in-class time to work on the assignment, but also scheduled time outside of class

to meet with group members. Technologies were used by instructors and students in the blended and online sections of the course, both during and outside of class, to facilitate group work.

Cooperative learning approaches are defined as the "instructional use of small groups so that students work together to maximize their own and each other's learning" (Johnson et al., 2014, p. 87). For example, in the undergraduate teacher education course in the present study, a learning assignment was designed for a small group of students, requiring them to cooperate with their peers and prepare a coherent unit plan. Similarly, in the teaching profession, it is common for teachers to work with colleagues to plan a unit together. Hence, learning how to work in a peer group to design a unit plan is an important professional skill for teachers to experience in their teacher education program (Alberta Education, 2018). Instructors can create conditions to support cooperative learning in group work (Clarke & Blissenden, 2013), and through careful design, group work can support productivity, communication, problem solving, and strengthening of relationships (Darling-Hammond et al., 2008). Interdependent relationships fostered during group work can support a culture of learning (Friesen, 2009; Johnson et al., 2014), and technologies can contribute to success when learning in a group (Gronseth & Hebert, 2019).

Collaboration is a term also used to describe groups working together. With over 30 years of research on teacher collaboration, Hargreaves (2019) argues there are factors that must be considered when designing such activities for positive results. He notes that professional collaboration matters, and developing collaborative cultures in schools could lead to higher levels of academic achievement and learning gains for students. For example, schools with high levels of teacher-professional collaboration have shown a connection to students' learning gains in mathematics and reading (Goddard et al., 2007). Professional collaboration can positively impact student learning and teacher

performance (Ronfeldt et al., 2015). Teachers who work collaboratively with their colleagues report greater job satisfaction and are more likely to remain in the profession (Hargreaves, 2019; OECD, 2018). However, collaboration can also present challenges and be less efficient and more difficult for group members to manage (Berlin & White, 2012; Thom, 2020). In group work studies in post-secondary settings, faculty and students reported issues such as limited interactions and time zone differences when working on group assignments in online courses (LaBeouf et al., 2016).

Learning in Groups in Teacher Education

Learning in groups in teacher education can be defined broadly as an educational mode of active learning and student-to-student interdependence used to promote collaborative inquiry and cooperative learning (Clark & Blissenden, 2013; Johnson et al., 2014; Johnson & Johnson, 2018). Such learning can be structured as a learning activity or an assignment in teacher education courses. In a study investigating 21st century skills needed for workforce preparedness in fields including education, the four most in-demand skills were "oral and written communication, collaboration, and problem solving" (Rios, 2020, p. 88). Designing group assignments can help undergraduate students develop these professional skills.

Johnson and Johnson (2017) describe the instructional design for groups in four steps. First, make a number of pre-instructional decisions. Instructors specify the objectives for the lesson; they decide both academic and social skills, the size of groups, the method of assigning participants to groups, the roles participants will be assigned, the materials needed, and the arrangement of the room. Second, explain the task and the positive interdependence. Instructors clearly define the assignment, teach the required concepts and strategies, specify the positive interdependence and individual accountability, give the criteria for success, and explain the expected social skills to be used. Third, monitor

participants' learning and intervene within the groups to provide task assistance or to increase participants' interpersonal and group skills. Finally, assess participants' learning and help them process how well their groups functioned. In teacher education programs, learning in groups has been shown to be challenging for pre-service teachers (Brown et al., 2018; Thomas & Brown, 2017) but has also resulted in unexpected positive outcomes, such as the development of important workplace skills, including leadership skills among aspiring teachers (Thomas & Brown, 2019).

Technology-Supported Group Work

Technology can support group work (Hmelo et al., 2013) and innovative teaching (Donovan et al., 2019), and help distinguish how each individual contributes to group work (Clarke & Blissenden, 2013). Hammond (2017) examines learning approaches in online environments and describes further benefits for online group work, such as greater reach, opportunity for combining different forms of media, and gathering an archive of the interaction and knowledge sharing among group members. Moreover, Kleinsasser and Hong (2016) describe how group members interact in online spaces, "where students encourage and facilitate each other's effort to complete tasks online by offering mutual assistance and creating mutual influence" (p. 570). Bickle and Rucker (2018) examined student-to-student interactions in asynchronous online courses and found that using technology with group assignments provides students with a more humanizing method of interaction and influences their feeling of community and their ability to learn and communicate. There are benefits to instructors and students when engaging in knowledge-building activities such as group work in participatory learning environments (Jacobsen et al., 2013).

In a literature review focused on technology-supported group work in large online courses, Manathunga and Hernández-Leo (2015) found the research in higher-

education settings mainly involved technologies used by the institution (e.g., learning management systems). Technologies supported group formation, online discussions, and peer assessment; however, there were fewer activities that required higher coordination, such as collaborative writing or knowledge building. Less is known about the technologies selected by students and instructors that support group work (Kleinsasser & Hong, 2016; Roseth et al., 2011). It is important to learn more about the choice of technology and how this can support learning in groups (Alqurashi, 2019). Further research is needed to examine what technologies students are using when learning in groups and how technologies are used by instructors to support group work.

Theoretical Framework

Morton Deutsch (1949) is known for framing social interdependence theory. This theory is often applied to educational studies involving group work (Johnson & Johnson, 2005, 2018). Recognizing that learning in groups requires positive interdependence among members (Johnson & Johnson, 2008), the researchers used the basic five elements of social interdependence theory to inform this study. The five elements are: interdependence, individual accountability, interaction, social skills, and group processing (Johnson & Johnson, 2017).

Positive Interdependence

Positive interdependence refers to the notion that success becomes attainable by working with others in the group. Learning designs involving group work require positive interdependence and the understanding each member contributes to the overall success of the group. Interdependence is related to collective efficacy and the idea that success is dependent on the combined efforts of the group. Self- and collective efficacy are connected and, as described by Bandura (2001), highly efficacious

individuals work well together. For example, researchers note that in schools where collective teacher efficacy is strong, teachers have more self-efficacy (Donohoo, 2018). Others have also detailed a positive relationship between collective teacher efficacy and student achievement (e.g., Donohoo & Katz, 2017; Eells, 2011; Goddard et al., 2007). In other words, a sense of collective efficacy among a group with shared goals and resources can lead to positive outcomes.

In relationship to beginning teachers, findings demonstrate increased retention and fewer new teachers leaving the profession when teachers are working in environments with a strong sense of collective teacher efficacy (Tiplic et al., 2015). Group work "promotes a situation in which students work together in small groups to maximize the learning of all members, sharing their resources, providing mutual support, and celebrating their joint success" (Johnson & Johnson, 2002, p. 96). Similarly, Boyle et al. (2019) argue that group work helps students to learn to work together rather than competitively and develop respect for each other. Synchronous opportunities for group work, where members meet at the same time, can contribute to collective efficacy. In a study comparing face-to-face and online settings of a learning activity, researchers used two dimensions to examine social interdependence: synchronicity and the type of medium or resources used (audio, video, text-based) for interactions (Roseth et al., 2011; Saltarelli & Roseth, 2014). It is interesting to note that these researchers found that perceptions of interdependence were high during both face-to-face and technology-supported synchronous exchanges. Technologies can be used by remote groups to work on aspects of a group assignment synchronously.

Individual Accountability

Individual accountability promotes positive interdependence (Johnson & Johnson, 2005) and is also an important consideration for designing group work activities. Individual

accountability recognizes the value that each member contributes to the success of the group, and reduces "social loafing" in group work (Laal et al., 2013). In a study about online group work with undergraduate music education students, the different levels of individual participation in the group were noted as an area for improvement (Biasutti, 2011). Individual accountability in online spaces needs to be considered for keeping each group member accountable for their contributions.

Interaction

Promotive interaction in social interdependence theory is defined as "individuals encouraging and facilitating each other's efforts to complete tasks and achieve in order to reach the group's goals" (Johnson & Johnson, 2002, p. 97). During face-to-face interactions, promotive interaction provides verbal and non-verbal responses. In a review of 34 studies in face-to-face promotive interaction and conducted between 1995 and 2017, findings suggested "students' interpersonal behavior, their experiences and active participation in the cooperative learning process, communication and support to each other, and teachers' influence on promoting students' interaction" lead to successful small group work (Kristiansen et al., 2019, p. 1). Promotive interaction needs to be considered in online learning spaces as well.

Social Skills

Social skills are an essential component in social interdependence theory. Group members need an opportunity to "(a) get to know and trust each other, (b) communicate accurately and unambiguously, (c) accept and support each other, and (d) resolve conflicts constructively" (Johnson & Johnson, 2005, p. 320). In other words, working in groups can help develop relationships (Jaques & Salmon, 2007). Socially-skilled students can promote positive relationships among groups and problem solve.

Social skills can support making decisions as a group, dealing with conflicts, building trust, and engaging in effective communications to support the group task.

Group Processing

Group processing is a mediating variable that examines how groups can achieve their goals and maximize learning. In social interdependence theory, group processing can take the form of reflection on group work (Johnson & Johnson, 2002). A process of continually doing so can help groups make decisions about next steps and make changes while the learning is taking place. Group processing is an integral part of group work that can positively impact success as long as there are sufficient time and clear expectations for group processing.

Another mediating variable for effective group work described by Kleinsasser and Hong (2016) is the importance of shared spaces for group interaction and how this contributes to positive interdependence as students provide mutual support for each other. Working together in a group to accomplish shared goals requires positive interdependence, and technologies can be used to support learning in groups. This article focuses on examining the following research question and interpreting the results through the lens of social interdependence theory: What types of technologies were used, and how were they used by students and instructors to support learning in groups in blended and online sections of a teacher education course?

Research Design and Methods

Design-based research (DBR) (Amiel & Reeves, 2008; Dai, 2012; McKenney & Reeves, 2018) was used for this 2-year study to explore group work in a required teacher education course offered in blended and online formats. In the course, pre-service teachers were tasked with developing a unit plan in small groups. How group

assignments are designed can influence the success of the work (Roberson & Franchini, 2014), and a more systematic approach is needed (Mamas, 2018). Hence, the overall study aimed to explore how a DBR approach could inform the instructional re-design of the group assignment in the course. Part of the study examined what technologies were used, and how, to support group work in blended and online sections of the teacher education course. Researchers intentionally designed the study to include all sections of the teacher education course and report findings as an aggregate instead of comparing or contrasting the sections based on the mode of delivery. For purposes of this paper, the authors report on the data and findings specifically related to the technologies students and instructors used and how these supported learning in groups.

In Year 1, students and instructors were invited to complete an online survey during an 8-week academic term. Following completion of the course, researchers interviewed students and instructors to gather in-depth descriptions about their experiences using technology to support group work. Three iterative phases of DBR (investigation/analysis, design/prototyping, and evaluation/retrospection) were followed to help inform the re-design and systematic changes made to the group work assignment for all sections of the course in Year 2, using the data collected in Year 1 (Barab, 2014). Year 1 findings also helped refine the instruments used for data collection in the study. The data collection procedures were repeated in Year 2. It is beyond the scope of this article to detail the design phases and changes made to the group assignment in Year 2.

This article aims to report on the results from the second year of the study related to what technologies were used, and how, to support group work in one teacher education class with multiple sections that were offered in both blended and online formats.

Context and Recruitment

Located in a post-secondary institution in Western Canada, a required teacher education course was used to study group work and learn more about the technologies used by students and instructors when learning in groups. The pre-service teachers in the course were in the final year of their undergraduate education program (4-year degree) at the time of the study, and the course involved a common assignment requiring students to work together in small groups (four to five members) in the 8-week course to develop an interdisciplinary unit plan. There were 14 sections of the course during the first year of the study and 16 during the second year. Each section had an enrolment of 21–35 students in different disciplinary areas and levels (e.g., elementary and secondary) of specialization.

Instructors in all sections were invited to participate in the study each year. They were recruited first to determine the number of sections of the teacher education course that would be involved in the study. In Year 1, there were six sections, and in Year 2, there were nine sections of the course that took part in the study. Following this, a member of the research team met with the students in each section to describe the study and invite them to participate. In the sections that were instructed by members of the research team, the recruitment was conducted by a research assistant to minimize pressure to participate. Students and instructors who provided consent to participate in the study were surveyed at three different times during the term: during the beginning, middle, and end stages of the group assignment. The interviews with students and instructors took place after the completion of the course to make sure the students did not perceive any conflict with their participation in the study and overall grade in the course.

Methods

Ethical clearance through the research ethics board from the institution was secured prior to conducting the study. Mixed methods of data collection were used: surveys and semi-structured interviews.

Surveys for Students and Instructors

The survey was administered three times to instructors (six in Year 1; nine in Year 2) and students (210 in Year 1; 151 in Year 2) during the term (beginning, middle, and end) while the students were working on their group assignment. The online survey for students and instructors included a number of questions related to instructional designs involving learning in groups. It is beyond the scope of this paper to present all of the findings from the broader study.

Respondents were asked to reflect on the current week in the course when the survey was administered and respond to questions about how they used technologies to support group work. Students responded to questions about how they used technologies that week to work on their group assignment. Instructors responded to questions about how they themselves used technologies to support the students in their section with the group assignment. The surveys took 10–15 minutes to complete. Results from Year 1 informed the changes made to the survey in Year 2. For example, in Year 1, the survey asked respondents to list how technologies were used as an open-ended text response. Analysis from Year 1 helped establish common categories and a list of options for the Year 2 survey.

In the Year 2 survey, when participants were asked in a mult-select question how technologies were used to support group work, the options included: technology was used to support communications, technology was used to support the unit design,

technology was used to obtain resources, technology was used to organize our group, and technology was used for idea generation. The options were generated from the list of common responses in the Year 1 survey. In Year 2, there was also an option at the end of the question to manually enter a response and describe additional ways technologies were used during the week to support learning in groups.

The next questions were dependent on the respondent's selections to the previous multi-select question. For example, if a respondent selected in the first question that technologies were used to support communications, then using survey logic, the subsequent question asked the respondent to select the types of technology that were used to communicate with group members. Commonly used technologies determined from the Year 1 survey were listed, and respondents used a five-point Likert scale to indicate the amount of use for each technology: (5) a great deal, (4) a lot, (3) a moderate amount, (2) a little, and (1) none. The selections were determined from the list of common responses in the Year 1 survey and included learning management system (LMS) discussion forums, virtual meetings (Adobe Connect), shared Google documents, communication applications, and email. Respondents also had the option to manually enter a response and list other types of technology that were not included in the list. Descriptive statistics were used to interpret and analyze the quantitative data (see Tables 2 and 3) that resulted from the survey questions.

Interviews with Students and Instructors

Semi-structured interviews (~30–60 minutes) were conducted with instructors (six in Year 1; five in Year 2) and students (nine in Year 1; four in Year 2) after the course was complete, and grades were submitted. Six questions were asked during the interviews, including: What technologies did you use to support group work? Interviewers probed further to gather detail about how the technologies were used. Technologies were also

discussed by the participants when the researchers asked other questions about group work: What are the challenges you experienced with student collaboration? How was your learning supported in the group assignment? Do you have anything else you would like to share with researchers? Responses to the interview questions helped the researchers develop a deeper understanding about the types of technologies selected and how students and instructors used these to support learning in groups. The interview transcripts were analyzed using Miles et al. (2014) coding cycles. In the first cycle of coding, descriptive codes were recorded by the researchers. A second pass of the qualitative data helped the researchers collapse the descriptive codes into themes. This rigorous process of two-cycle coding by the research team served to provide credible and trustworthy findings.

Findings

Findings are reported for how students and instructors used technologies to support group work in both blended and online sections of a teacher education class. Table 1 outlines the numbers of student and instructor responses from the three surveys administered during the second year of the study at the beginning, middle, and end of the course. Out of 16 sections of the course, nine instructors agreed to participate in the study and gave the researchers permission to introduce the study to their sections. Of the nine sections, 261 students were invited to participate in the study, and a total of 151 students (58%) from both online and blended sections agreed to participate in one or both phase(s) of the studies (surveys and interview). The participants had the option to complete one, two, or all three surveys during the 8-week term, followed by an interview after completion of the course.

Table 1

Frequency of Survey Responses and Response Rates for Repeated Survey in Year 2

	Instructor responses	Response rate	Student responses	Response rate
Survey 1	9	100%	121	81%
Survey 2	6	67%	100	66%
Survey 3	7	78%	60	40%
Total	**22**		**281**	

How Technology Supported Group Work

Findings indicated that technology was used by students for purposes of process and product when working with peers on a group assignment, and by instructors for the same purposes when supporting students in that work. For process, technologies were used primarily to support communications and manage challenges by both instructors and students, and for product, technologies were used to coordinate shared workspaces, track and monitor progress, and complete the group product.

When asked in the multi-select question of the survey how technology was used to support group work, there was a total of 2072 responses from student-respondents across the three surveys. The two responses with the highest frequency for how technology supported students with their group work were: to support communication with group members (n = 360) and to support designing the unit plan with the group (n = 333). Instructors were also asked how they themselves used technology to support students' group work in their sections of the course, and there was a total of 102 responses from instructor-respondents across the three surveys. The selections with the highest frequency from the instructor responses across the three surveys were

consistent with the student responses: to support communications with students (n = 20) and to support students with designing the unit plan (n = 17). Students and instructors reported using technologies to support communications (process) and completing the group assignment (product).

Types of Technologies Used for Communications

Survey respondents were asked to specify the types of technologies that were used for communications to support group work and the extent of use (e.g., a great deal, a lot, a moderate amount, a little, or none). Table 2 shows the means and standard deviations for the student and instructor responses regarding the amount of time they used each technology. The three student responses with the highest means were: shared Google documents, email, and communication applications (apps). The three responses with the highest means for instructors were: email, LMS discussion forums, and shared Google documents. This data shows student-respondents selected Google documents as technology used a great deal during Surveys 1, 2, and 3. Google documents were used frequently by students when compared to email, apps, and the LMS in all three surveys. Instructors reported using LMS discussion forums and email in all three surveys. However, when responding to the third survey, instructors also selected Google documents as a technology they were using a moderate amount. A minimal number of respondents manually entered additional technologies that supported communications (e.g., texting, website creation tools, presentation software) beyond the list of options provided in the survey question.

Table 2

Extent of Use of Technologies for Communications: Means and Standard Deviations for Student and Instructor Responses

		Students		Instructors	
		M	SD	M	SD
Survey 1	Shared Google documents	4.03	1.24	2.67	1.8
	Apps	2.16	1.45	1.83	0.69
	Email	2.71	1.42	3.50	1.50
	LMS discussion forum	1.91	1.02	3.67	1.11
Survey 2	Shared Google documents	4.46	0.85	1.75	1.30
	Apps	2.38	1.53	1.25	0.43
	Email	2.60	1.49	3.75	1.30
	LMS discussion forum	1.57	0.97	3.25	1.79
Survey 3	Shared Google documents	4.48	0.82	3.00	1.53
	Apps	2.35	1.54	1.33	0.47
	Email	3.04	1.54	3.50	0.96
	LMS discussion forum	1.54	0.95	3.00	1.29

Interview analysis showed that students and instructors were using a combination of applications such as email, shared Google documents, and apps (e.g., *WhatsApp*, *Facebook Messenger*, texting, group chats) to support group communications. Interview participants described the types of technologies and specifically named the programs or applications that were used. All interviewees mentioned a combination of technologies used to communicate with group members. Students described using a combination of technologies (e.g., *Facebook Messenger*, Google apps) for communication, assigning roles and responsibilities, and managing timelines. Similarly, instructors discussed how a combination of technologies were used for communication (e.g., *WhatsApp*, Google apps). Instructors used online LMS discussion forums and described this tool as a way to coordinate student groups and monitor progress. The survey and interview responses indicated both students and instructors used a combination of technologies for communication.

How Technologies Were Used to Support Communications

In the interviews, students referred to the way technology (e.g., *Facebook Messenger*, Google documents) was used to communicate with their group members throughout the process for coordinating group activity, sharing documents, and sending quick messages to each other. Interviews with instructors were consistent with the survey results and also revealed how they were using technologies to support students with their group work. Instructors described using Google documents and email to communicate feedback to students and answer questions. Instructors also described using the online LMS discussion forum to collect group contracts, review draft work, and check in with groups. Instructors used the LMS discussion forum to support communication and for keeping students accountable in their work. Some discussed using the forum as a space for students to post draft work and noted how this contributed to accountability and making learning visible. Both students and instructors

discussed the value in having flexibility to select a combination of technologies for their group work communications.

Types of Technologies Used for Developing a Group Product

In the survey, students and instructors indicated that technology was used to develop their group product. Respondents were asked to specify the type of technologies that were used to support doing so and the extent of use (e.g., a great deal, a lot, a moderate amount, a little, or none). Table 3 shows the means and standard deviations for the student and instructor responses regarding the amount of time they used each technology to develop the group product. The technologies used by students based on the highest means were: (1) shared Google documents, (2) email, and (3) apps. The highest means for technologies instructors used to support students developing a group product were: (1) shared Google documents, (2) LMS discussion forums, and (3) email. This data shows student-respondents selected Google documents as a technology used a great deal to develop a group product. During Surveys 1 and 2, instructors reported using Google documents more often to support students in developing their group product. A minimal number of respondents manually entered additional technologies that supported developing their group assignment (e.g., word processing software, website creation tools, online resources, whiteboard) beyond the list of options provided in the survey question.

Table 3

Extent of Use of Technologies to Support Group Assignment: Means and Standard Deviations for Student and Instructor Responses

		Students		Instructors	
		M	SD	M	SD
Survey 1	Shared Google documents	4.03	1.25	3.25	1.79
	Apps	2.00	1.45	1.00	0.00
	Email	2.43	1.47	1.75	0.83
	LMS discussion forum	1.82	1.07	2.75	0.83
Survey 2	Shared Google documents	4.44	0.85	4.00	1.73
	Apps	2.06	1.40	2.00	1.73
	Email	2.28	1.50	3.75	1.3
	LMS discussion forum	1.48	1.0	4.00	1.22
Survey 3	Shared Google documents	4.52	0.89	2.40	1.02
	Apps	2.24	1.51	2.80	0.75
	Email	2.51	1.56	1.20	0.40
	LMS discussion forum	1.60	1.08	3.40	1.62

Students reported using the same three technologies to support communications (Table 2) and developing their group product (Table 3): shared Google documents, email, and apps. However, instructor-participants did not have the same responses for technologies used to support communications as for technologies used to support the group product. For example, in Surveys 1 and 2, instructors selected Google documents, LMS discussion forums, and email as the three most frequently used technologies to support students in developing their group product. However, in Survey 3, instructors did not select email and instead selected apps as a way to support students. Consistent among all survey responses from students and instructors was the use of Google documents to support both communications and completion of the group product.

How Technologies Supported Developing the Group Product

During the interviews, students described using shared workspaces to complete their group product. They detailed how technology was used to coordinate, track, and monitor their progress and collaboratively work together to complete their group product. For example, students discussed using Google documents to collaborate online and to design their unit plans. One student noted how information from Google documents was accessed by group members and how they could build on the work. Another student pointed out how Google documents were used to help manage their group work to develop their unit plans. Students described how technologies were used to assign roles and responsibilities and provide a space to contribute their work.

Students also reported challenges while co-designing the unit plan, and difficulties dividing the workload and then integrating the parts, but noted how technology was used to mitigate the challenges and work asynchronously. For example, in one interview, a student shared how their group used technology (e.g., Google documents) to divide the workload and put it back together to create a coherent product with

students contributing at different times. Apps (e.g., *WhatsApp*, *Facebook Messenger*, texting, group chats) were also used to manage group challenges related to scheduling and for integrating tasks into the project. This demonstrates the expanded functions of many communication applications and how these are not limited to group member communications but can also be used for completing the group product.

Similarly, the instructors who were interviewed reported how they used technology to support their students in completing the group product. Instructors described how students shared their Google documents to receive instructor feedback. Instructors were also invited to contribute to shared Google folders set up by the students and to observe their process.

Consistent with the survey results, the interview participants provided perspectives about how students and instructors used a combination of technologies to support communication and completion of the group product. The findings identify the type of technologies students reported using to do so. Students selected their shared workspaces for group work (shared folders, shared documents) and used communication applications (instant messaging applications, email) to support their group work. They described using technologies to manage group challenges related to scheduling, communicating, and developing a coherent group product. Instructors also reported using institutionally supported applications (e.g., LMS discussion forums) to support group work and communications. Although many of the same technologies were used for both process and product, the interviews detailed how students and instructors used a combination of technologies to support instructor-student and student-student communications, and how technologies were used to overcome challenges to complete the group assignment.

Discussion

Learning in groups requires positive interdependence, so social interdependence theory (Johnson & Johnson, 2005; 2018) was used as a lens to interpret the findings related to the research question that framed this inquiry: What types of technologies were used and how were they used by students and instructors to support learning in groups in blended and online sections of a teacher education course? The five elements of social interdependence theory (Johnson & Johnson, 2005; 2018) are shown to connect to the types of technologies selected and the ways they were used by students and instructors to support the communication process and completion of a group product: interdependence, individual accountability, interaction patterns, social skills, and group processing.

Interdependence

A combination of technologies was used by students and instructors to support group communication and completing a group assignment (Hmelo et al., 2013). More specifically, shared workspaces (e.g., Google documents), apps (e.g., *WhatsApp*, *Facebook Messenger*, texting, group chats), and email were used for combining efforts (Hammond, 2017) and for communications needed to work together and interdependently (Johnson & Johnson, 2002). Groups used these technologies to assign roles, responsibilities, and timelines related to their work, which in this particular course was to co-design a unit plan. The group assignment required interdisciplinary expertise, and members needed each other for its completion (Hammond, 2017; Johnson & Johnson, 2002). Students used technologies that offered opportunities for group members to contribute asynchronously (Google folders and documents). Groups also needed support through ongoing feedback from their instructor when working on the assignment. In this study, instructors supported group interdependence by engaging with groups using

technologies (e.g., Google documents, email, LMS discussion forums) to communicate, clarify learning outcomes, and provide feedback for the success of the group work in completing the product and managing challenges. Participants reported using a combination of technologies to support group work, including to communicate and work towards a common goal, share resources, support one another, and work interdependently.

Individual Accountability

Technologies were also selected and used in this study as a way for individuals to contribute to the overall success of their groups at flexible times. Students took responsibility for completing their work and supporting their group members in completing the group task (Johnson & Johnson, 2005) at times when they worked together synchronously and when they contributed asynchronously. Interview participants discussed how technologies made individual accountability visible (Clarke & Blissenden, 2013). For example, instructors used institutionally supported technologies (e.g., LMS discussion forums, email) to assign roles and responsibilities and gather group contracts that were visible to all group members. Using online spaces to post and share group contracts, as described by many of the instructors interviewed, can provide a way to communicate individual responsibilities and establish a shared understanding of the group assignment. Students reported using a combination of technologies to communicate with each other and the instructor (e.g., apps, email, Google documents), and used shared online spaces (e.g., Google documents) to visibly add their contributions and bring coherence to the group product (Kleinsasser & Hong, 2016). Using a combination of technologies, students and instructors reported they were able to monitor and track progress and review individual contributions (Clarke & Blissenden, 2013; Laal et al., 2003). Perhaps, the transparency of individual contributions available when using technologies for group assignments can be helpful

for groups working together interdependently (Johnson & Johnson, 2005). Further study would be required to determine how technologies can strengthen the level of individual accountability needed to accomplish a group assignment.

Interaction Patterns

Students and instructors in this study described how technologies (e.g., Google documents, apps, email) were used to foster interactions between instructors and students and between group members (Johnson & Johnson, 2002). Instructors reported how technologies were used to provide feedback to students working in a group (Kristiansen et al., 2019). Some instructors offered synchronous feedback and met with groups at scheduled times. Others provided asynchronous feedback, and students used the feedback to make improvements to their work. Shared online spaces were reported to provide a platform for keeping track of interactions, along with apps, which helped with managing group work and maintaining ongoing communications with the instructor and group members (Kleinsasser & Hong, 2016). Instructors and students described how a combination of technologies were used, and particularly how shared online spaces provided a space for synchronous and asynchronous interactions.

Social Skills

Learning in groups helps students establish working relationships (Jaques & Salmon, 2007). While working with a group to design a product using shared spaces (e.g., Google documents) and apps, participants in this study described how they communicated with and supported each other in completing the assignment (Johnson & Johnson, 2005). Data specifically related to the use of social skills were not gathered; however, instructors and students who were interviewed reported how technologies helped mitigate challenges related to scheduling, communicating, and integrating tasks into the project. Students and instructors discussed using technologies to coordinate

shared workspaces, track and monitor progress, and complete the group product. Working with a group is an important professional skill required by teachers entering the workforce (Alberta Education, 2018).

Group Processing

Group processing can occur when members reflect on their actions (Johnson & Johnson, 2002). The group assignment in this study was designed with group processing in mind and required members to reflect on their individual and group contributions as part of the work. As an indicator of group processing, instructors and students described using online spaces to communicate with each other and use feedback to inform next steps (Kleinsasser & Hong, 2016). From a methodological perspective, participants were also provided with opportunities to reflect on the ways technologies were used to support group work at three different points during the course (Surveys 1, 2, and 3) and after its completion through individual interviews. Further research could examine how instructors and students use ongoing records of contribution for group processing as part of the assignment and as part of the data collected for a study.

Limitations

Despite the limitation that this study was based on multiple sections of only one course, with each section taught by a different instructor, researchers were able to identify the types of technologies used and the ways they supported group work in an undergraduate education course. The group assignment was designed in the same way for blended and online sections of the course. The study was not intended to compare or contrast blended and online sections, and data were aggregated for its purposes. This approach could be viewed as a design limitation of the study, or can help inform instructional designers contemplating how to design group work for different modes of course delivery. Social interdependence theory proved to be a useful lens to interpret

the findings, and helped the authors recognize that further study is needed to understand how a combination of technologies selected by students, instructors, and institutions can impact group process and product.

Conclusion

Findings from this study showed that technologies selected by students and instructors can support students with process and product when learning in groups in blended and online environments. Students and instructors shared how they used a combination of technologies to support communication and completion of the group product. While engaging in group work, students and instructors used technologies that were institutionally supported (e.g., LMS, email), but most often they selected other mainstream technologies that allowed for asynchronous and synchronous contributions by the group and the instructor (e.g., Google documents, apps). The results from this study contribute to our understanding about the types of technologies used and how a combination can support group work. This study also contributes to a growing body of research indicating that technologies can be used to promote social interdependence when students are learning in groups.

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