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Abstract

As rehabilitation technologies rapidly develop, the lack of evidence-based training remains a barrier to technology adoption. Continuing education (CE) may provide training opportunities for new technologies, specifically 3D printing. Current models of CE course design rely on traditional, pedagogical methods, including didactic delivery, as opposed to applying adult learning models, which integrate experiential, self-directed learning to promote collaboration and problem-solving. This study sought to determine whether the active learning approach of peer-assisted learning (PAL) promoted collaboration and transference of knowledge between rehabilitation clinician peers when learning 3D printing. In this mixed methods study, 35 clinicians from occupational therapy, physical therapy, and speech language pathology disciplines participated in two hours of CE, which integrated tenets of PAL to explore attitudes toward technology adoption perceptions as measured by the Technology Acceptance Model (TAM). Pretest and posttest results were analyzed using paired permutation tests. All TAM responses improved significantly ($p < .05$), suggesting that for rehabilitation clinicians, CE using an andragogical PAL approach contributed to improving technology acceptance of 3D printing. Content analysis of posttest open-ended questions further explored PAL implementation. The qualitative themes were: (1) Active opportunities supported learning, (2) group format facilitated problem-solving within a team, (3) technology was easier than expected, and (4) barriers remain for technology application in practice. In conclusion, the themes support the integration of PAL as a delivery method of CE to enhance technology adoption.

Keywords

Continuing education; 3D printing; peer-assisted learning; interprofessional education

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ABSTRACT

As rehabilitation technologies rapidly develop, the lack of evidence-based training remains a barrier to technology adoption. Continuing education (CE) may provide training opportunities for new technologies, specifically 3D printing. Current models of CE course design rely on traditional, pedagogical methods, including didactic delivery, as opposed to applying adult learning models, which integrate experiential, self-directed learning to promote collaboration and problem-solving. This study sought to determine whether the active learning approach of peer-assisted learning (PAL) promoted collaboration and transference of knowledge between rehabilitation clinician peers when learning 3D printing. In this mixed methods study, 35 clinicians from occupational therapy, physical therapy, and speech language pathology disciplines participated in two hours of CE, which integrated tenets of PAL to explore attitudes toward technology adoption perceptions as measured by the Technology Acceptance Model (TAM). Pretest and posttest results were analyzed using paired permutation tests. All TAM responses improved significantly ($p < .05$), suggesting that for rehabilitation clinicians, CE using an andragogical PAL approach contributed to improving technology acceptance of 3D printing. Content analysis of posttest open-ended questions further explored PAL implementation. The qualitative themes were: (1) Active opportunities supported learning, (2) group format facilitated problem-solving within a team, (3) technology was easier than expected, and (4) barriers remain for technology application in practice. In conclusion, the themes support the integration of PAL as a delivery method of CE to enhance technology adoption.

Introduction

Assistive technology (AT) facilitates opportunities for people with disabilities to engage with their environment and participate in meaningful activities (Boisselle & Grajo, 2018), which includes devices customized for the user (Assistive Technology Act, 2004). Occupational therapy (OT) practitioners are trained through formal entry-level education on AT device design, application, and training and are qualified to provide the service delivery of the device (Accreditation Council for Occupational Therapy Education [ACOTE], 2023; American Occupational Therapy Association [AOTA], 2021). It is well established that OT practitioners, physical therapy (PT) professionals, and speech-language pathologists (SLPs) frequently collaborate within interdisciplinary teams to provide optimal patient care. While OT practitioners are primarily recognized for their involvement with AT, PT professionals and SLPs contribute significantly to this specialized area. According to the respective scope of practice documents from the American Physical Therapy Association (APTA) and the American Speech Language Hearing Association (ASHA), PT professionals may engage in the prescription, application, fabrication, or modification of AT to improve functioning (APTA, 2023). SLPs apply their knowledge using advanced instrumentation and technologies, such as augmentative and alternative communication devices (ASHA, 2016). Although applications of technology are broadly included in entry-level education for these clinical disciplines, there is still a significant knowledge-to-practice gap regarding their ability and preparedness to utilize rehabilitation technology in practice (Curtis et al., 2023), as the specifics of the type of AT are at the purview of each accredited entry-level program. As practice areas become more specialized, clinicians are encouraged to pursue continuing education (CE) to address the complex needs of patient care, including in AT. Of particular concern is that among AT service providers, a relatively higher proportion of PT and SLP practitioners reported that their AT professional education was inadequate as compared to OT practitioners (Arthanat et al., 2017). Understanding the evidence-based learning processes of how clinicians learn and accept the training of technologies may be useful in designing CE coursework to provide specialized and appropriate AT for people with disabilities and considering how CE is designed to assure effective learning and acceptance of emerging technologies in rehabilitation.

Models of Adult Learning

Traditionally, CE coursework applies a pedagogical model integrating subject-based lectures or presentations (Chacko, 2018; Knowles, 1980). In contrast, an andragogical, or adult learning model, focuses on experiential and self-directed learning through the participatory process of problem-solving and collaborating (Chacko, 2018; Knowles, 1980). In the review of supporting evidence, experiential learning in healthcare-focused curricula improved learning outcomes (Henning et al., 2008; Knecht-Sabres, 2013) and enhanced confidence and perception of self-efficacy when learning and applying hands-on patient skills (Knecht-Sabres, 2013). Specifically, in the context of learning technologies, experiential and hands-on learning improved students' learning through mentorship and feedback (Benham & San, 2020; Giesbrecht et al., 2020).

Within experiential learning, peer-assisted learning (PAL) is a method that encourages collaboration between peers and allows the transference of knowledge between colleagues (Olaussen et al., 2016). Educational strategies within PAL include peer teaching and learning, peer tutoring and feedback, peer modeling and mentoring with leadership, and cooperative learning using small groups to facilitate working together (Al Kawas & Hamdy, 2017). These strategies occur within similar social groupings, allowing those with a similar knowledge base and learning experiences to explain concepts appropriately to their peers (Topping & Ehly, 1998). These strategies are demonstrated between near-peers when learners who are more experts in the content are directed to mentor the learners who are novices, or between learners who are encountering new material together (Tai et al., 2016). Peer-assisted learning tenets implemented within allied health and medical educational programs are an effective, often incidental, supplement to didactic curricula, increasing self-confidence and acquisition of clinical skills (Henning et al., 2008; Fonda & Ross, 2023). In clinical education, peer assessment and feedback have been studied for nursing and medical students, with research supporting learning outcomes and overall clinical experiences (Henning et al., 2008). Pairing PAL techniques when teaching technology during didactic education increased favorable perceptions, intention to use, and student performance with the technology (Benham et al., 2022; de Sam Lazaro & Riley, 2019). Consistent with PAL tenets, interprofessional learning groups may provide the opportunity for collaboration and transference of knowledge among clinicians of differing expertise levels, as each profession provides a unique perspective that, when brought together, provides natural opportunities for peer learning and mentoring (Keijsers et al., 2016).

Although PAL has demonstrated favorable outcomes, little research is available on applying experiential learning to CE course design and efficacy in healthcare, specifically in the area of rapidly changing technology in rehabilitation. Few studies have explored the relationship between experiential learning and knowledge outcomes for clinicians; most focused on a blended teaching model with inconclusive results (Babiss et al., 2017, Doherty-Restrepo et al., 2009; Ward Zaghab et al., 2015). This suggests a disconnect between current CE course delivery and evidence-based learning retention methods; as mentioned previously, even less is known regarding AT training in rehabilitation.

3D-Printed Assistive Technology

As AT service delivery is ever-changing, 3D printing is an emerging technology not fully adopted by practitioners yet offers the unique opportunity to meet patient needs through accessible AT. 3D printing is known as an additive manufacturing technology by building an object, and in this case, an AT device object, from a three-dimensional digital model through a layer-by-layer process, solidifying the material (Alexander et al., 2021). 3D-printed AT is growing in popularity among clinicians, and for individuals living with physical disabilities, 3D-printed AT may increase participation and independence due to its high customizability potential to meet their specific needs (Rasmussen et al., 2022; Schwartz et al., 2019; Thorsen et al., 2023; Turkistani & Qurban, 2022). Benefits of 3D-printed AT include functional performance outcomes, low cost of production with lightweight materials, and overall user satisfaction (Benham et al., 2023; Portnoy et al., 2020; Schwartz et al., 2019; Schwartz & Schofield, 2021). However, limited clinician training and skills hinder implementation and result in varying effectiveness (Huber et al., 2023; Schwartz & Schofield, 2021; Van Lieshout et al., 2022). These barriers lead to the justification of further 3D printing training research to potentially lead to greater adoption in rehabilitation.

To facilitate the adoption of new technology in rehabilitation, the Technology Acceptance Model (TAM) helps researchers understand the barriers and facilitators faced by healthcare professionals that influence acceptance (Davis et al., 1989). Usability or usefulness is a relevant consideration as clinicians prefer technology that is easy to use and has the potential to improve patient outcomes (Atwal et al., 2014; Bower et al., 2021; Liu et al., 2015; Tobis et al., 2017). Among OT personnel, with limited support and knowledge of developing 3D printing technology, acceptance is limited despite expressing positive attitudes and the intention to use it (Slegers et al., 2022). A recent study developed 3D printing coursework for OT practitioners with reports of increased technology acceptance (Barter et al., 2023), however, the adult learning approach of the course format was not defined and was not expanded to include recommendations for interprofessional education (World Health Organization [WHO], 2010), which would model the collaborative team approach to problem-solving and enhance services. Despite favorable attitudes toward 3D printing technology, novel technology training coursework designed for adult learners who value active learning has not been explored. Therefore, the primary objective of this study was to determine if CE integrating an andragogical PAL approach improved technology acceptance of 3D printing among rehabilitation clinicians. The secondary objective was to explore the perspectives of adult learning within CE courses to understand if PAL approaches positively contributed to the learning and acceptance of novel technologies.

Methods

Study Design

The research design used a mixed methods approach to explore whether acceptance perceptions of 3D printing changed from pre- to post-training and gain perspectives on PAL as a model for CE. Data collection followed a sequential strategy in which the quantitative data was collected first, represented by the TAM pretest and posttest measures, followed by qualitative data collection via an open-ended written questionnaire completed by each participant after the CE (Creswell & Creswell, 2017).

Instruments

The tool used was a pretest and posttest questionnaire based on the TAM to collect data on clinicians' perceptions of 3D printing prior to beginning the course and after completing two contact hours of CE (Davis et al., 1989). The TAM was developed to understand acceptance behaviors based on two categories. The category of *Perceived Usefulness* is defined as the user's belief that the technology will improve their ability to complete their work. The category of *Perceived Ease of Use* captures if the user finds the technology free of effort. *Perceived Usefulness* and *Perceived Ease of Use* together influence *Attitude Toward Using*, which may predict users' motivations and change their actual usage in the *Intention to Use* (Davis et al., 1989).

A seven-point, Likert-based modified TAM questionnaire was used to measure 15 questions of clinicians' *Perceived Usefulness* (questions 1-4), *Perceived Ease of Use* (questions 5-9), *Attitude Towards Using* (questions 10-13), and *Intention to Use* (questions 14-15) ranging from 1 (strongly disagree) to 7 (strongly agree), specifically regarding 3D printing technology. Internal consistency is high for the TAM (α=0.91) (Hong & Walker, 2015), and the questionnaire was utilized in previous research with items adjusted to apply to clinical work (Benham & San, 2020). Open-ended questions included in the posttest questionnaire were designed as targeted questions to provide additional information about the CE course, specifically regarding the PAL format. These questions were: 1. “Please share your thoughts on the course format.” 2. “What are your thoughts on bringing your clinical expertise to this course to work together collaboratively in small groups?” 3. “What are any barriers to learning and utilizing 3D printing in your practice setting?” 4. “Did this course accommodate your learning needs and preferences? Why or why not?” 5. “Did your perceptions of using 3D printing for patient care change after completing this course? How?” and 6. “Please share additional comments or feedback to share with the presenters.”

The demographic written form included requests to self-report the participants’ age, gender, ethnicity, identification of clinician discipline, years licensed, previous experience using 3D printing, and practice setting. Licensed rehabilitation clinicians (including occupational therapists, occupational therapy assistants, physical therapists, physical therapist assistants, and SLPs, hereby referred to as clinicians) from one health network representing both inpatient and outpatient settings were recruited for this study. Inclusion criteria were: 1. Current licensure in Pennsylvania as a rehabilitation clinician as described above, 2. Current employment with the rehabilitation network sponsoring the CE, and 3. Agreement to participate in two contact hours of CE, which was held in person. The Moravian University Human Subjects Institutional Review Board (IRB) approved this expedited study and agreed to provide ethical oversight for the project.

Procedures

Rehabilitation clinicians employed by the rehabilitation network were recruited via the employer email listserv with information on the CE sessions and how to enroll. Upon providing signed informed consent, the clinician was enrolled as a participant. Then, the demographic form and the TAM pretest were completed. The CE format outline integrated the tenets of PAL, described in Table 1. The research team developed the course together based on their experiences with 3D printing. The sessions were led by the 3D Printing Clinical Specialist with a background in physical therapy, an occupational therapist with research experience in 3D printing, and at least two research assistants who were occupational therapy graduate students to model as the “peers” to lead the small group learning format. After completion of CE, participants were provided the TAM posttest form and the posttest open-ended questionnaire.

Table 1

Continuing Education (CE) Course Outline and the Alignment with Peer-Assisted Learning Tenets

3D Printing CE Outline	Alignment with PAL Tenets
Group member introductions with clinical backgrounds and shared thoughts on the potential benefits of 3D printing within their discipline and setting. Small groups were established of 4-5 clinicians with a peer group facilitator.	Members of similar social groupings familiarized themselves with other group members within a small group setting (Al Kawas & Hamdy, 2017).
Group facilitators (i.e., a member of the research team) demonstrated and described 3D printing examples of successful past devices, and furthered discussion about how clinicians may implement 3D printing in their own practice settings through their clinical experiences.	Facilitators used peer leadership to teach peer learners through modeling and demonstration. Peers then collaborated within their small groups and provided additional ideas and feedback to their peers, drawing from previous knowledge (Knowles, 1980; Olaussen et al., 2016).
Utilizing software (i.e., pre-designed models) and hardware, such as calipers for measurement, furthered the discussion of enhancing communication between clinicians and the 3D Printing Clinical Specialist.	Facilitators modeled material usage and encouraged small group participation and collaboration to promote further discussion. Expert facilitators were present to demonstrate effective communication between clinicians of varying experience levels (Tai et al., 2016).
Facilitators demonstrated exporting AT device models and the setup of the 3D printer, which then facilitated discussion of 3D printing limitations and feasibility regarding various devices.	Active participation from the learners with the peers performing each step. Small group discussion and peer feedback were provided by the expert facilitators (Topping & Ehly, 1998).
Application of individual clinical expertise while applying the post-production adaptation applications. This included smoothing, the use of heat guns to reposition and size, applying velcro and Dycem, and the use of paint markers for higher contrast.	Group members collaborated with their peers to receive and provide peer feedback based on their own clinical experiences (Knowles, 1980; Olaussen et al., 2016).
Discussion of using patient-reported outcome measures upon device delivery to ensure patient satisfaction with the AT device.	Group facilitators prompted small group discussions and offered the opportunity to share applicable experiences. (Al Kawas & Hamdy, 2017; Knowles, 1980).

Problem-solving to search other pre-created designs through open-access sharing sites, and offered the opportunity for group brainstorming of novel ideas for AT devices with the clinicians.	Group facilitators modeled ways in which peer learners could expand upon their learning and knowledge. Peer learners were encouraged to collaborate within small groups to provide peer feedback. (Al Kawas & Hamdy, 2017; Olaussen et al., 2016).

Note: CE= Continuing Education; AT=Assistive Technology

The CE course design and delivery were developed and implemented using the PAL approach to teaching and learning, focusing on adult learners who brought a wealth of clinical experience to the sessions. Sessions were limited to a maximum of 10 participants who learned in small groups (4-5 clinicians in a small group) with hands-on access to a 3D printer at the workstation (Figure 1a). The small group setting facilitated solving clinical problems and applied peer teaching, learning, feedback, and mentoring from the research team throughout the small group collaboration (Figure 1b).

Figure 1

Course Set-Up to Facilitate Hands-on Learning (a.) and Small Group Collaboration (b.)

Data Analysis
Descriptive statistics were used to summarize the demographic characteristics of the clinicians. Due to smaller sample sizes and evidence of non-normality, paired permutation tests were used to analyze whether posttest TAM scores were higher than pretest TAM results for each individual TAM question. These tests also evaluated the average differences across the four categories of the TAM. The matched pairs permutation test is a nonparametric, simulation-based method of statistical inference. The test statistic is reported as the original average of the differences in pre- to post-scores; the p-value is computed as the probability of observing this difference as or

more extreme under a simulated null distribution, assuming no difference in pre- and post-test scores, that is generated using a large number of replications (e.g., 10,000) (Bonnini et al., 2014; Kuiper & Sklar, 2012). The significance level was set to $\alpha = .05$ with effect sizes calculated. We analyzed data using the statistical software R (R Core Team, 2022). As a posthoc analysis, given the almost equal proportions of inpatient and outpatient participants, a permutation test between the independent groups' pretest to posttest differences for each of the TAM categories was analyzed.

A directed approach to content analysis was utilized to analyze the open-ended questions (Hsieh & Shannon, 2005). The targeted questions were directed regarding the potential predetermined categories of PAL, specifically feedback on the course format and learning preferences, group learning, and barriers drawing from their clinical expertise and the intention to use it in their daily routine. The first author (SB) read through all participant responses to ensure the potential categories had emerged to understand if and how PAL contributed to the changes in technology acceptance of 3D printing. The first author (SB) then randomly assigned interviews to code among the research assistants, the second through fourth authors (CD, AD, EH), for each interview to be coded by two research assistants independently, following the predetermined coding scheme of course format and learning preferences, group learning, and barriers. This approach allowed for tracking commonalities and interpretation of the textual data and potentially identifying new categories that emerged during the analysis process, while remaining flexible to make meaning of unanticipated data (Hsieh & Shannon, 2005). To ensure trustworthiness, each research assistant reflected and documented their potential biases before coding which were discussed and considered by the primary author. If there were discrepancies in codes, a third research assistant confirmed the coding agreement through discussion, along with the oversight of the primary author on final decisions. Themes of PAL were derived from participants' synthesized responses and supplemented the understanding of changes in technology acceptance of 3D printing.

Results

To achieve power of 80%, planning for $\alpha = .05$ with a two-tailed analysis and an estimated effect size of 0.660 in the TAM category of *Intention to Use*, we sought to recruit at least 21 participants (Benham et al., 2020). To plan for the potential attrition of working clinicians with variable scheduling conflicts, we aimed to recruit a minimum of 28 clinicians. Thirty-five participants enrolled and completed the CE session of 3D printing clinical applications over four weeks of offering the coursework. There were no dropouts, which resulted in 100% retention. The research team ran four available sessions in the afternoons after the standard clinical workday, with attendance at each session ranging from 8 to 10 participants split into small groups of 4 to 5.

Quantitative

Demographic information of the sample (n=35) is outlined in Table 2. The majority of participants were female (n=34, 97.1%) and were all (n=35, 100%) novices in 3D printing. Our primary research question explored whether a PAL-formatted CE course improved the acceptance of 3D printing technology among rehabilitation clinicians. All individual pretest to posttest TAM questions indicated significant increases ($p < .05$) in agreement with the statements (see Table 3). Questions corresponding to each of the four TAM categories were summed and then divided by the number of questions in each category to calculate the average for each category (see Table 4). This method of analysis is consistent with previous reports on TAM category changes (Benham et al., 2022). All TAM categories significantly increased ($p < 0.05$) from pretest to posttest and resulted in relatively large effect sizes, which may be interpreted as small effect (0.20), medium effect (0.50), and large effect (0.80; Cohen, 1988).

As a post-hoc analysis, given the similar participant group sizes of 17 inpatient clinicians (48.6%) and 18 outpatient clinicians (51.4%), we analyzed the differences in pretest and posttest responses of the TAM categories across the two independent groups. No significant differences were present in technology acceptance responses between clinical settings ($p > .05$).

Table 2

Participant Demographics (n=35)

Characteristic	**Mean (SD) or *n* (%), [Range]**
Age (Years)	44.8 (12.9), [Range: 25-65]
Professional Title	
Occupational Therapist	9 (25.7%)
Occupational Therapy Assistant	4 (11.4%)
Physical Therapist	12 (34.3%)
Physical Therapy Assistant	6 (17.1%)
Speech-Language Pathologist	4 (11.4%)
Years Licensed	18.2 (12.5), [Range: 1-42]
Gender	
Female	34 (97.1%)
Male	1 (2.9%)
Ethnicity	
White	33 (94.3%)
Asian	2 (5.7%)
3D Printing Competence	
Novice	35 (100%)
Primary Practice	
Inpatient	17 (48.6%)
Outpatient	18 (51.4%)

Note. SD = standard deviation

Table 3

TAM Pretest and Posttest Questionnaire Scores (n=35)

TAM Category	Question	Response, M (SD)		*p*
		Pretest	Posttest	
Perceived Usefulness	1. I think that using 3D printing would improve work performance for clinicians.	6.14 (0.73)	6.69 (0.47)	< .001
	2. I think that using 3D printing will improve the effectiveness of how clinicians deliver services.	6.14 (0.77)	6.60 (0.60)	< .001
	3. I think that the advantages of using 3D printing outweigh the disadvantages.	6.31 (0.80)	6.74 (0.44)	< .001
	4. Overall, I think that using 3D printing is useful.	6.57 (0.56)	6.77 (0.43)	.007
Perceived Ease of Use	5. I think that learning to work with 3D printing (will be/is)* easy.	4.63 (1.00)	5.57 (1.07)	< .001
	6. I think that learning 3D printing (will be/is)* clear and understandable.	5.17 (0.86)	5.91 (0.85)	< .001
	7. I think that it (will be/is)* easy for clinicians to become skillful at using 3D printing.	5.06 (0.91)	5.69 (0.99)	< .001
	8. I think that it is possible to use 3D printing without expert help.	3.37 (1.54)	4.40 (1.72)	< .001
	9. The use of 3D printing is attainable for the everyday clinician.	4.37 (1.35)	5.89 (0.90)	< .001
Attitude toward Using	10. I think that using 3D printing is a good idea for clinicians.	6.00 (1.06)	6.66 (0.48)	< .001
	11. I think that 3D printing is a useful tool for treatment.	6.17 (0.82)	6.66 (0.48)	< .001
	12. As a clinician, I like the idea of using 3D printing.	6.43 (0.56)	6.86 (0.36)	< .001
	13. 3D printing is realistic to use in my practice setting.	5.77 (1.03)	6.57 (0.50)	< .001

Intention to Use	14. I plan to implement the use of 3D printing in my practice.	5.66 (1.16)	6.54 (0.66)	< .001
	15. I will recommend the use of 3D printing to other clinicians.	6.17 (0.86)	6.77 (0.43)	< .001

Note. M = mean; *SD* = standard deviation; TAM = Technology Acceptance Model. Scale: 1 = *totally disagree,* 2 = *disagree,* 3 = *somewhat disagree,* 4 = *neutral,* 5 = *somewhat agree,* 6 = *agree,* 7 = *totally agree.*
*Questionnaire was altered from pretest to posttest to reflect changes in verb tense.

Table 4

Summary Values of Clinicians' Average Scores within the TAM Categories (n=35)

TAM Category	**Pretest M (SD)**	**Posttest M (SD)**	**Difference M (SD)**	***p***	**Effect Size (Cohen's *d*)**
Perceived Usefulness	6.29 (0.71)	6.70 (0.49)	0.41 (0.53)	< .001	0.78
Perceived Ease of Use	4.52 (1.13)	5.49 (1.11)	0.97 (0.68)	< .001	1.44
Attitude toward Using	6.09 (0.70)	6.69 (0.39)	0.59 (0.64)	< .001	0.93
Intention to Use	5.91 (0.87)	6.67 (0.50)	0.74 (0.87)	< .001	0.86

Note. M = mean; *SD* = standard deviation; TAM = Technology Acceptance Model. The "Difference" column contains the average of the differences as data are paired; Cohen's d is based on these differences.

Qualitative
To identify how PAL approaches may have contributed to the learning and acceptance of novel technologies, content analysis was completed, and four main themes emerged that related to technology acceptance reports: (1) Active opportunities supported learning, (2) the group format facilitated problem-solving within the team, (3) technology was easier than expected, and (4) barriers remain for technology application in practice.

Theme One: Active Opportunities Supported Learning
Active learning was integrated within the course format using interactive, hands-on tasks that promoted active participation throughout the course, as well as clinically relevant visuals and demonstrations, followed by various teaching and learning approaches that were clear and conducive to learning. Roughly half of the participants reported that hands-on learning opportunities contributed to active learning, with a participant stating that they "appreciated the interactive format" (Participant 32).

Theme Two: Group Format Facilitated Problem-Solving within a Team

Subthemes related to the facilitation of interdisciplinary collaboration and effective learning through group interaction. Specific modes of interaction identified in the analysis were discussions, brainstorming and problem-solving, and sharing interdisciplinary perspectives. Participants reported that the small group problem-solving format was enjoyable, helpful, and easy, with participants commenting that "small group in person is a great way to learn this material" (Participant 04). Participants also valued interdisciplinary collaboration, with one stating that "it was good to get perspectives from other disciplines/specialties" (Participant 24). This small group format allowed for the realistic application of the content.

Theme Three: Technology was Easier than Expected

Perceptions of 3D printing technology were reported by participants as being easier or more accessible than expected, with participants stating that there were "more possibilities than I even thought possible" (Participant 06), and that "it is much easier and cheaper than I thought" (Participant 05). There were also reports of the technology being not "easy" or seemingly complicated until the hands-on component of the CE course was initiated, with participants stating that the information was "Overwhelming until hands-on. Very easy" (Participant 02). Overall, perceptions of the process of applying the technology were positive after completion of the course, and one reported, "I had no idea of the use in 3D printing" (Participant 07).

Theme Four: Barriers Remain for Technology Application in Practice

An overarching theme emerged that barriers potentially limit the carryover of 3D printing technology into everyday clinical practice. Subthemes identified were the time constraints of the 3D printing and service delivery processes. Depending on the setting, these included plan of care timelines (i.e., time limitations of evaluation to discharge of the plan of care), followed by sanitation and durability of materials, and concerns regarding lack of confidence in technology expertise. It was indicated that time, whether it be time limitations of the rehabilitation professional or patient length of stay, was the most reported barrier to 3D printing reported by almost half of the participants. These results indicate that there were still concerns regarding the acceptability of 3D printing in everyday rehabilitation settings. Identifying barriers also further allows researchers to understand how likely rehabilitation clinicians are to adopt this technology. Participants reported that they were likely to adopt the technology, with one participant commenting, "I would like to use this resource more for my patients" (Participant 27). Another participant stated that the course, "Increased my willingness to use with patients" (Participant 30).

Table 5 outlines key quotes supporting the themes identified.

Table 5

Participant Quotes Related to Identified Major Themes

Theme	Key Quotes
1. Active Opportunities Supported Learning	*"...felt overwhelming until hands-on. Very easy."* (Participant 02) *"Appreciated the interactive format."* (Participant 32)
2. Group Format of Problem-Solving within a Team	*“...easy to learn in small group and hands on learning.”* (Participant 03) *"Small group in person is a great way to learn this material."* (Participant 04) *"It was good to get perspectives from other disciplines/specialties…"* (Participant 24)
3. Technology was Easier than Expected	*“I realized it is more accessible to use than I thought."* (Participant 08) *"It is much easier and cheaper than I thought."* (Participant 05) *"Easier to set up the printer & make custom designs than I thought."* (Participant 19) *"I would like to utilize this resource more for my patients."* (Participant 27) *"Increased my willingness to use with patients and try different devices."* (Participant 30)
4. Barriers Remain for Technology Application in Practice	*"More complicated/complex than I thought regarding the downloading process and file formatting. I imagined this would not be simple, but was just not what I expected."* (Participant 15)

Discussion

The purpose of this mixed-methods study was to provide a larger picture to explain the quantitative findings with supportive qualitative data analysis.

Quantitative Data

For the statistical analysis of all TAM questions and categories, all *p*-values were less than 0.05 (see Tables 3 and 4). This indicates a change in technology attitudes following the course. In the category of *Ease of Use,* there was a significant change in pre to posttest scores ($p < 0.001$). The results in the category *Ease of Use* may likely determine a user’s *Intention to Use* based on previous research that supports the relationships between these categories and clinician preferences to use technology that is easy to use (Bower et al., 2021; Davis et al., 1989).

Our study included participants 25-65 years of age, and all participants across this wide range of representative ages and years of experience [years licensed range: 1-42] responded favorably in the technology adoption reporting. We also found through a post hoc analysis that there were no differences observed between the settings of the participants (i.e., inpatient and outpatient settings), implying that new and experienced clinicians across different patient care practice settings have positive attitudes towards using new and developing technologies after training. Previous research suggests a relationship exists between clinicians' *Perceived Ease of Use*, *Perceived Usefulness*, and *Intention to Use*, specifically, *Perceived Ease of Use* which can be impacted by sufficient training and education (Abdekhoda et al., 2019). Similarly, our results represent a significant change from pretest to posttest in all four categories of the TAM specific to 3D printing. This suggests that similar results are possible with other technologies through thoughtfully designed training protocols considering the adult learner and the wealth of experience brought to the educational training sessions. Further qualitative analysis, as described below, delves into explanations.

Qualitative Data

By analyzing the themes derived from the PAL tenets and the subthemes synthesized using clinician responses, we determined the benefits of using PAL in CE. Within the first theme of active opportunities supporting learning, participants reflected upon the influence PAL had on promoting active learning, which included hands-on opportunities, visuals, demonstrations, and the provision of several different learning styles that were conducive to learning. Through opportunities for active participation came relevant conversations and problem-solving related to the course content. Active learning and small group collaboration worked together to support the participant's learned knowledge, as indicated through the TAM scores and open-ended discussion questions.

Regarding the second theme of small group formats, a primary tenet of PAL integrated into the CE was that interdisciplinary small groups promoted peer learning and problem-solving (Al Kawas & Hamdy, 2017). A significant benefit of integrating small group problem solving, as reported by clinicians, was the opportunity for interdisciplinary discussions and exchanging practice-based experiences. With the use of small groups to promote interprofessional, interactive discussion, participants were able to collaborate and participate in peer teaching and learning, providing the opportunity to learn from one another. This method of learning was preferred for technology-based content.

In alignment with the *Perceived Ease of Use* category improvements, qualitative findings support the third theme that the technology was easier than the participants expected. This may have been supplemented by the PAL tenet of active learning, as the interactive learning format of PAL also promoted changes in the perception of the 3D printing process. In addition, our qualitative data shows the perceptions of affordability of 3D printing technology, which can be related to the *Perceived Usefulness* category of TAM because affordable AT increases patient access and is useful in achieving functional outcomes.

Regarding the fourth theme, barriers that remain for technology application in practice, the promotion of small group discussion and problem-solving allowed for reflection upon barriers that remain that limit implementation, including time constraints and material. Understanding the barriers helps the research team to understand if rehabilitative clinicians will adopt 3D printing technology into their practice settings; however, most indicated that they were likely to adopt it. To understand the likelihood of clinicians using 3D printing, the TAM category of *Intention to Use* may represent intended actual use. Our results ran parallel to Curtis et al. (2023) who reported that a significant correlation existed between clinicians' motivation and implementing a new technology.

To further support our study's quantitative results, participant responses reflected a high likelihood of technology adoption in the TAM category *Intention to Use*. This is a good indicator of 3D printing adoption, as perceived limitations are often the reason for technology abandonment in other forms of technology (Kruse et al., 2016). The results of our study, in the category of *Intention to Use,* are similar to previous research in that OT practitioners and OT students had positive attitudes toward 3D printing technology and the intention to use it (Slegers et al., 2022). Our findings also support the idea that a change in attitude supports the intention to use the technology (Davis et al., 1989).

In the context of the literature, the use of PAL in CE course design allowed for interdisciplinary teams to provide their unique perspectives within their small groups, promoting natural opportunities for an interdisciplinary transference of learning among peers (Keijsers et al., 2016), allowing further discussion of barriers. An interactive, collaborative environment was also promoted within the CE course design by implementing PAL tenets, including peer teaching, learning, modeling, and feedback (Topping & Ehly, 1998). Participating clinicians highly favored the implementation of PAL into the format of the CE course design, reporting the benefits of peer teaching and learning in overall learning outcomes.

In clinical education, PAL has always seemed to be an incidental supplement to an established curriculum (Fonda & Ross, 2023; Henning et al., 2008). However, when implemented directly within course design in clinical learning settings, PAL improved peers' experiences and learning outcomes (Henning et al., 2008). The direct use of PAL in the clinical education curriculum improved knowledge and self-confidence in performing a new skill and promoted collaborative learning among peer teachers and learners (Fonda & Ross, 2023). The use of PAL in CE produced a similar outcome, with our available qualitative data supporting the concept that a PAL-integrated course format improved clinical CE experiences and learning outcomes through collaborative, interprofessional learning. In the meta-analysis of interprofessional formal education programs, Guraya and Barr (2018) reported knowledge and skill acquisition improvements after embedding interprofessional education in various medical fields, along with opportunities to learn from one another. Our reported outcomes, which are novel to CE interprofessional collaboration outcomes, illustrate the benefits of interprofessionalism along with PAL.

In regard to technology adoption, factors in addition to training may sustain use and avoid abandonment among healthcare professionals. Individual preferences may affect the sustained use of technology, including interest and perceived autonomy to use it (Matthew-Maich et al., 2016). Overall, studies found that lacking technical knowledge and support may lead to low technology adoption and use rates in clinical practice, contributing to high technology abandonment (Dyb et al., 2021; Vaezipour et al., 2019). When combining the qualitative data with the quantitative analysis, our study may support how to prevent technology abandonment, potentially as PAL may contribute to technology acceptance by supporting clinicians through the active learning of technical knowledge acquisition. In addition, the small group problem-solving, identification of barriers, and promotion of changes in technology perceptions may positively affect the attitudes by not promoting autonomy but rather through a supportive group.

Limitations

The identified limitations of this study were largely related to the self-selection bias of participants who may be interested in technology and enrolling in the course. This study was offered only to a specific rehabilitation hospital network employees in one geographical location, which may contribute to biases in the sample. CE occurred in person directly following standard working hours, which may have been a barrier for a more diverse sample traveling from further locations or unavailability of work hours due to personal and family obligations. Limitations in the course design included that originally, we designed the course to be delivered over two sessions; however, due to time constraints and the concern for attrition, the course was condensed to two hours in one session. Fidelity was maintained by limiting the number of participants to 8-10 participants per session, with the same lead instructors delivering the course in the same setting, at the same time of day (in the afternoon), using similar scripts.

For the open-ended qualitative survey, some responses appeared unrelated to the question being answered or otherwise unclear. These responses could not be verified and interpreted when determining major themes to avoid misinterpretation. This may have been avoided if member-checking was implemented, however, this was not possible considering the de-identification and maintaining the confidentiality of the participants' responses.

It is understood that some participants who enrolled in our study already had an interest in or understanding of 3D printing and therefore did not change their *Perceived Usefulness* because the technology was already perceived as "useful" at the pretest (6.29 average reported at pretest or interpreted as in agreement). In addition, it is unknown if clinicians are requesting or implementing 3D printing with their patients immediately after the CE and over time longitudinally.

Suggestions for Future Research

We suggest further exploring adult learning principles within the continuing education course design. It would be beneficial to conduct similar research offered to a larger population of rehabilitation clinicians for a longer period to explore perceptions from a more representative sample. Similarly, it would be helpful to follow the PAL format in other CE courses regarding other forms of technology and to explore the relationships of demographics to technology acceptance, such as age and years licensed, to determine if these characteristics are also a factor in technology acceptance. Longitudinally, it would be important to follow up with participants about the adoption, or implementation, of 3D printing technology into practice. The next step in the research process would be to conduct a pretest to posttest study with a control group of participants who learn 3D printing in a traditional didactic format and compare it to a group of participants who learn in an active, andrological PAL format.

Implications for Continuing Education Course Design for Adult Learners

The results of this study support the integration of andragogical principles, specific tenets of PAL, including small group format and active, hands-on learning, into the continuing education of rehabilitation professionals to improve learning outcomes and carryover. Incorporating more hands-on, discussion-based educational demands may contribute to the utilization of taught material in future clinical practice, and subsequently, more favorable patient treatment outcomes.

Conclusion

This research study provided both quantitative and qualitative data regarding preferences of course design in the continuing education of rehabilitation clinicians. To promote learning for rehabilitation clinicians, participants benefit from the implementation of PAL tenets in CE course design, specifically small group discussion, peer mentoring, peer leadership, peer feedback, modeling, and visual demonstration. Interprofessional rehabilitation clinicians should continue integrating PAL in CE courses to promote continued competence and improve overall patient outcomes using developing technologies.

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