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Learning Outcomes of Hybrid In-Person and At-Home Orthosis Fabrication Instruction for Occupational Therapy Students

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ABSTRACT

Prior to the COVID-19 pandemic, occupational therapy students at one university received all orthosis fabrication education through an in-person laboratory-based environment supported by clinicians and instructional videos. Due to the pandemic restrictions, orthosis fabrication labs for occupational therapy students were transitioned to a hybrid in-person and at-home supported lab. Presently, there is no research investigating how a hybrid in-person orthosis lab and at-home orthosis fabrication experience impacts the professional practice skill development of occupational therapy students entering the workforce. This research examined the learning outcomes of participation in a hybrid orthosis fabrication experience consisting of one in-person laboratory-based experience and one at-home supported experience (instructional videos, written instructions, without instructor supervision). The research also explored the implications of this hybrid learning experience for future curriculum development. This qualitative study included two components: (1) Interviews with six occupational therapy graduates; (2) 26 student reflections following the hybrid learning experience. The results of this study highlighted three overarching themes: orthosis skill development; transferable skills development; future considerations for implementing a hybrid learning method. A hybrid learning approach provided unique opportunities for the scaling of independence and productive struggle to develop student competence in orthosis fabrication. This research provided insights for occupational therapy curriculum developers to modify educational approaches and effectively support students as they develop into competent occupational therapists.

Background

Teaching basic orthosis fabrication skills is fundamental to occupational therapy curricula. Occupational therapy programs educate students to “assess the need for orthoses, and design, fabricate, apply, fit, and train in orthoses and devices used to enhance occupational performance and participation” (Accreditation Council for Occupational Therapy Education, 2020, p.30). A well-designed orthosis can relieve pain, provide joint protection, prevent or correct deformities, and allow client engagement in daily activities (McKee & Rivard, 2004). Thus, orthosis fabrication is an essential skill for occupational therapists to enable client occupation (Schofield & Schwartz, 2020). When occupational therapy students engage in hands-on learning of orthosis fabrication, they feel more confident and prepared when they enter fieldwork experiences (Schofield & Schwartz, 2020). Learning orthosis fabrication is a hands-on activity, however, COVID-19 restrictions at the University of Toronto forced this learning to shift to a hybrid in-person and at-home online learning experience.

Hybrid Learning: In-Person and At-Home Learning of Orthosis Fabrication

Hybrid learning is a “thoughtful fusion of face-to-face and online learning experiences” (Garrison & Vaughan, 2008, p. 3). Prior to COVID-19, orthosis fabrication labs at the University of Toronto consisted of two separate in-person lab opportunities. However, due to pandemic restrictions, there was a sudden interruption in this teaching structure that required a rapid adjustment to the curriculum, and thus an at-home lab replaced one of the in-person labs to allow students to have two opportunities to create an orthosis. As such, a hybrid learning format consisting of two components was developed: 1) 3-hour in-person lab that involved: watching instructional videos prior to the lab, creating an orthosis with a peer, receiving support and feedback from instructors, and self-evaluating and testing the orthosis based on conditions provided in a case study; and 2) at-home lab that included: watching instructional videos prior to the lab, creating an orthosis independently at-home on someone who was not a student peer, and completing an assignment evaluating the created orthosis and reflecting on the case study related to the orthosis.

Effects of Hybrid Learning on Health Care Students

A pilot study examining the difference between teaching orthosis fabrication virtually or in a traditional in-person laboratory found no differences in quality of orthoses; however, they did not explore students’ experiences (Amerih et al., 2013). Mu et al. (2014) found that online and hybrid learning were comparable in doctoral occupational therapy students, but online learning cannot replace the human interactions involved in participating in clinical-based experiences (Khalil et al., 2020). Hybrid learning could potentially improve reflective skills, clinical reasoning, problem solving, and the ability to bridge the gap between theory and practice among health care students (Rowe et al., 2012; Wong et al., 2004), yet interpersonal and communication skill development may be perceived as inferior (Wong et al., 2004).

Overall, the studies point towards the potential of hybrid learning, however, there is limited research on the implications of hybrid learning on practice skill development, and the subjective experiences of students moving through the orthosis fabrication curriculum. As a result, the purpose of this study was: (1) to explore the learning outcomes of the hybrid in-person and at-home learning experience of orthosis fabrication, and (2) to explore the implications of this hybrid learning experience for future curriculum development.

Methods

This qualitative study consisted of two components: 1) one-hour semi-structured paired and individual interviews conducted on Zoom to gather a deeper understanding of student experiences and learning outcomes (see Table 1 for interview questions and prompts); and 2) retrospective analysis of reflection papers on their orthosis created in the independent at-home lab that students completed in 2020. The study was approved by the University of Toronto Research Ethics Board.

Participants

Participants were second year graduate level occupational therapy students who experienced the hybrid format in 2020*.* The participants provided written informed consent to participate in both parts of this study. All subjects participated voluntarily and did not receive compensation.

Data Collection

The recruitment process occurred seven months after the orthosis lab experience. A recruitment notice was emailed to 136 occupational therapy students from the 2020 cohort, inviting them to participate in a virtual group interview about their combined in-person and at-home learning of orthosis fabrication. Among the 136 occupational therapy students, six responded to the notice and provided an electronically signed consent to participate in the interviews. To ensure active engagement and inclusion of interested participants, the six interviews were scheduled promptly as students expressed interest over the span of five months. As a result, four interviews were scheduled, including two paired interviews and two individual interviews three to five weeks apart. Participants were interviewed 10 to 13 months after the orthosis lab experience. Interviews were recorded and transcribed for analysis.

The stem interview questions were developed based on Kolb's experiential learning theory (Kolb, 1984). The questions were derived from the four-stage learning cycle to explore the process of the students' thinking. The questions were written, reviewed, and approved by all members of the research team. Consensus and acceptance of the questions were reached before proceeding with data collection. Questions explored student experiences in the combined learning setting, the challenges they encountered during their learning, how the learning setting (in-person or at-home) influenced their approach, their experience, perceptions, and reflections and skills developed.

Table 1

List of Prompts and Interview Questions

Study Component	Example Questions
Reflection papers	What aspects of your orthosis would you change? How would you do this? How might experience gained during this "At-Home Orthotic Lab" inform your future practice as an Occupational Therapist?
Semi-structured interviews	What skills did you develop from your at-home orthosis lab experience that you would not have developed during the in-person orthosis lab? How did the combined learning process of having both an in-person and an at-home orthosis lab influence your learning of orthosis fabrication? What other areas/topics of learning in OT education would this teaching format have been beneficial to your skill development? How so? What elements from the hybrid in-person and at-home experience influenced your competency and clinical reasoning in orthosis fabrication? When thinking about the at-home orthosis lab, what are specific components that required more/less problem solving than the in-person lab?

Two months following the initial recruitment, a second recruitment notice to the same cohort of 136 occupational therapy students was sent, requesting access to the electronic reflection papers written one week after their at-home orthosis fabrication experience. In total, 26 students responded to the notice and provided consent for the team to electronically access and analyze the papers from the course database.

Data Analysis

Data analysis involved the examination of two sources of data: the reflection papers, and the interviews. The analysis procedure followed an inductive coding approach outlined by Saldaña (2021). Two investigators (AL, EL) used NVivo 12 Plus to code the reflection papers and interviews. The investigators undertook individual coding of the 26 reflection papers initially, using descriptive codes to summarize the main topics addressed in each excerpt. The reflection papers were analyzed first to gather a comprehensive understanding of students' immediate experience following the at-home orthosis lab. The investigators then met to discuss the descriptive codes that each investigator generated in their individual analysis of each reflection paper. In instances where differing codes emerged, the investigators engaged in discussions, and explored their respective thought processes to reach a consensus. This iterative process was repeated for each of the reflection papers.

The interviews were analyzed after the initial analysis of the reflection papers. This sequential approach allowed for a guided exploration of the interviews, and provided additional insights into the students' experiences, compared to the reflection papers alone. Findings from the interviews were coded within the existing list of identified themes and categories from the initial analysis of the reflection papers. Additional sub-themes were created to highlight the unique data from the interviews. After combining categorized data from both sources, the investigators met to categorize the codes into broader themes through discussion and mind mapping. This involved coding to identify commonalities, differences, and potential relationships between the categories established from both data sources. Major themes were determined based on the number of references associated with the categorized codes. By merging the findings from both data sources, a more comprehensive understanding of the research objectives was achieved, represented by major themes and sub-themes.

Results

The qualitative analysis revealed three main themes and corresponding sub-themes, as noted in Table 2.

Table 2

Summary of Main Themes and Sub-Themes

Main Theme	**Sub-Themes**
Orthosis Skill Development	Critical thinking
	Technical skills of orthosis fabrication
	Perceptions of competence
Transferrable Skills Development	Communication
	Progression of independence along a continuum
Future Considerations for Implementing a Hybrid Learning Method	Facilitators of learning
	Challenges to learning
	Implications for hybrid learning of other clinical skills

Orthosis Skill Development
This theme overarches the development of both the hands-on technical skills and the cognitive processes specific to orthosis fabrication.

Critical Thinking
Critical thinking in this paper follows the definition of “conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication” (Scriven & Paul, 1987, para. 3). Using this definition, interview participants identified there were limited opportunities for critical thinking because the labs focused more on the technical skills of orthosis fabrication. This was highlighted in the interview with Student 1 stating:

> I don’t remember even the people, the faculty, or clinicians really referring to the case along the way, they were just kind of looking at like “does that look right”, you know, positioning wise, is it coming down far enough? Is it pinching? How are your edges? Things like that. I couldn’t really tell you, I think it was carpel tunnel, but I couldn’t really tell you because we didn’t really refer to the case at any point. But again, I think it was about learning how to work with the material and things like that, that was the sense I got.

Written reflections demonstrated an ability to identify a problem with their orthosis and most outlined a solution to this problem or considered a solution for the future. For example, Student 2 noted, “the material is shifted medially and doesn’t come around the radial side enough. I would change this by not making the cut to the web space so deep as it led to everything being shifted”.

Working at-home required students to problem solve and adapt, given the limited resources and tools that were available. As Student 3 noted in an interview:

> For the [at-home] lab, we had none of the equipment that you would normally have for making a splint, so you had to be creative like I... boiled it on the stove the first time which destroyed the material and then I realized that I could put in like a kettle, and then in a container and dipped it like the way that you would do like rice paper wrappers like.

Technical Skills of Orthosis Fabrication
The technical skills of orthosis fabrication referred to the understanding of the orthosis-making process and the biomechanical requirements. Students described that after completing both labs they had developed further knowledge and understanding about the orthosis-making process and the associated biomechanical requirements. They also reported learning basic orthosis skills from the in-person lab including handling equipment, molding material, and identifying issues related to discomfort. As stated by Student 4:

> But what I was able to gather, or like transfer from like the labs was like, how to do it, I was like okay like I need, like the steps of making it and making sure that like try to make sure that your, your pen marks aren't showing and like curve, or flare out the thing and like flare out the orthotic. Make sure that it's comfortable, it’s not causing redness…learning how to make one even not that type, like how

> to like use the materials and mold them and cut them. And like, modify it when, which is the worst thing when you like kind of done it already. How to modify it afterwards… So you're learning a lot of the practical skills that you need to build to a splint, like how to avoid sharp edges, where to roll it, how to roll it properly, how to use a heat gun, stuff like that that are very technical skills that help you build your clinical reasoning or make you consider things I wouldn't have considered in that home lab.

Students reported that the at-home lab provided further independent practice of the in-person orthosis lab skills. Specifically, they reported independent practice of adjusting the fit and client positioning. As Student 5 reported, “This practice was also helpful for learning how to position my client and work with them to create a comfortable and functional orthosis specific to their occupational needs”.

Perceptions of Competence

Students perceived a degree of incompetence in their ability to demonstrate orthosis fabrication skills. However, despite their perceived incompetence after the two labs, students described an increased understanding of foundations for orthosis fabrication. For example, Student 3 reported:

> I would probably want to practice on someone before I do it on a client, 'cause I never want to embarrass myself or seem incompetent in front of my clients so, yes, it would require a lot of prep work, but I do think [...if] I do have to build this splint, I could do it independently with prep, so that means I have the foundations.

Students noted they would need to prepare a great deal in advance before feeling competent in creating an orthosis again in their occupational therapy practice, but felt they had the foundations to prepare adequately.

Transferrable Skills Development

Findings suggest that students who participated in this hybrid in-person and at-home learning of orthosis fabrication developed transferable skills, namely communication and independence.

Communication

Analysis revealed that the at-home lab offered an opportunity for students to practice and develop communication skills. Students found that working with a family member or friend at home required them to modify instructions into lay language that was more appropriate for their “client.” Student 6 reported that when “doing it at home with someone who did not know much about the orthosis I was making, also gave me a chance to practice my communication skills with them that I can use in future practice.”

Conversely, for the in-person lab, students worked with another occupational therapy student and one interview participant mentioned that peers made “very easy clients”. Peers modeling as clients had some familiarity with the orthosis fabrication process, including how to position their hands, and the technical language of orthosis fabrication.

Students did not need to intentionally communicate in lay language. One student also found they communicated more with their at-home "client", compared to the in-person lab to receive feedback about the comfort and functionality of the orthosis, while for the in-person lab, their peer would offer that feedback without first being asked.

Progression of Independence Along a Continuum

Although students did not perceive they were fully independent in orthosis fabrication by the end of the two labs, they reported a growing independence with each lab. As such, the development of independence can be better understood as a continuum. Student 7 reported that "it felt like a transition from, ok first you're going to do it at the university in a very traditional way. You're going to be guided completely. Now, you're going to transition into doing it [...] more on your own."

During the in-person lab, students received guidance, support, and feedback from instructors throughout the fabrication process. However, the at-home lab was completed independently in the absence of instructors, fostering greater independence. Students were required to problem solve on their own, particularly in finding equipment and tools that replicated ones they used in the in-person lab. Students did not feel they could perform orthosis fabrication independently by the end of both labs; however, despite the lack of expert support at home, students were aware of supportive tools and resources that they could access, such as re-watching the instructional videos.

Future Considerations for Implementing a Hybrid Learning Method

After participating in this hybrid learning, investigators gathered feedback about the learning experience itself, focusing on aspects that facilitated learning, challenges to learning, and whether this hybrid learning could be applied to other clinical skill development.

Facilitators of Learning

Students found that receiving instant feedback and support from clinicians and peers in their immediate physical environment supported students' learning of this novel skill.

The chronological order of having an in-person supported lab first, followed by an independent at-home lab was an important factor. Students learned skills for orthosis fabrication in the in-person lab, and then independently applied what they learned in the at-home lab. Many students recognized technical mistakes made during the in-person lab (e.g., setting the water temperature too high or too low; allowing the thermoplastic to stick onto itself when handling the material), and these mistakes became learning opportunities that helped them feel more prepared for what to expect in the at-home lab.

Students reported that the at-home lab reproduced similar aspects of a clinical setting, including having a mock client and problem solving independently. They noted that fabricating an orthosis at home with improvised equipment was similar to making an orthosis for a client in their home (i.e., home care). Several students had similar overall impressions, as quoted by Student 8, "this at-home orthotic lab gave me a glimpse of how I might be working in clinical settings."

Challenges to Learning

Many students reported they felt rushed during the three-hour in-person lab, however, they acknowledged that more time would not necessarily have made a difference, given it was their first experience making an orthosis.

Challenges to learning in the at-home lab included: lack of proper equipment, lack of immediate feedback or support from instructors and peers, and lack of guidance in clinical reasoning to help connect the related case study to the orthosis created. The lack of proper equipment (e.g., curved scissors) resulted in students feeling they did not create an orthosis that was of equal quality compared to if appropriate equipment was available. The lack of immediate feedback or support from instructors and peers prevented students from seeking immediate assistance in the same way that occurred during the in-person lab. Students reported that their peers worked on the at-home orthosis assignment at different times, so when students faced obstacles, they had no one to reach out to for immediate support or feedback. Additionally, students perceived the absence of instructors or peers in the at-home lab to limit their ability to apply clinical reasoning skills and build a deeper understanding of the orthosis as it related to the case study provided. In the in-person lab, instructors walked through the case study with students and asked probing questions which students reported helped to build their clinical reasoning skills.

Implications for Hybrid Learning of Other Clinical Skills

Interview participants were asked to reflect on other clinical occupational therapy skills that might benefit from being taught through a similar hybrid format. Students suggested the following clinical skills: manual patient handling techniques; neuro developmental treatment (NDT) facilitation techniques; mobility aids prescription and training (e.g., wheelchair prescription); Cognitive Orientation to daily Occupational Performance (CO-OP) approach; conducting cognitive assessments; and home safety assessments.

Students reported that they learned these clinical skills through completely in-person or completely virtual means, but expressed that a hybrid approach could have further benefited their learning. Students felt a hybrid approach would have allowed them to learn and practice a skill with an instructor's guidance before practicing the skill with a mock client.

Discussion

Three learning theories/approaches provide an explanation of the themes generated by the analyses of the hybrid orthosis learning experience: Kolb's (1984) experiential learning theory, scaffolded learning, and adaptive expertise. Kolb's experiential learning theory differentiates between the in-person and the at-home labs, particularly when considering the stages of abstract conceptualization and active experimentation. Completing an in-person lab and then at-home lab created a scaffolded learning opportunity that enabled scaling of independence. The notion of adaptive expertise provides a framework to describe how the hybrid lab supported the development of conceptual knowledge through the creation of productive struggle, fostering future application. These concepts can be used to explore adaptation of future orthosis fabrication education for occupational therapy students.

Kolb's experiential learning theory can be used to differentiate a completely in-person lab experience, and a hybrid lab format, which focuses on the stages of abstract conceptualization and active experimentation (Kolb, 1984). The hybrid lab encouraged students to transfer their learnings from the in-person university-based lab to the at-home lab that mimicked an unstructured clinical setting, thereby demonstrating reflection of new ideas or idea modification (abstract conceptualization) in addition to independent experimentation with their modified concepts or ideas in a semi-structured at-home environment (active experimentation). For example, the in-person lab helped students understand the importance of material preparation and familiarization with the steps of orthosis fabrication. Students then independently applied this knowledge during the at-home lab with a "client." This increased freedom and responsibility allowed for a wider range of abstract conceptualization and experimentation to adapt tools and work around challenges without support.

This hybrid experience enabled a scaffolded learning opportunity that facilitated scaling of independence. Intentional scaffolded learning is effective even when teaching complex skills (Chernikova et al., 2020). A gradual modification of supports promoted learning and independence (Rodger et al., 2014). The in-person lab allowed for shared guidance (Ten Cate et al., 2004) between the instructor and the student, where instructors provided guidance and support to students during the lab, while students engaged in self-guided learning of orthosis fabrication prior to, and during the in-person lab via instructional videos. The at-home lab scaffolded learning towards greater independence as learning was largely internally guided and self-driven. Immediate feedback and support from the in-person lab was scaled back in the at-home lab. This pushed students towards greater independence in utilizing their learned knowledge from their in-person lab experience to internally guide them through problem-solving, and decision making in the at-home environment (Ten Cate et al., 2004).

Adaptive expertise provides a framework to describe how the hybrid lab fostered the creation of productive struggle. According to this framework, three factors must be present when developing expertise: (1) procedural knowledge which includes the *what* questions or *how to* do things, such as the process of orthosis fabrication; (2) conceptual knowledge includes the *why* questions that require clinical reasoning, such as why things are done; (3) productive struggle creates challenging conditions thereby fostering problem-solving and improved conceptual knowledge by building one's ability to generate new solutions (Mylopoulos et al., 2018a, 2018b).

Procedural knowledge was developed during the in-person lab and further practiced in the at-home lab which allowed for productive struggle. Although students reported uncertainties, they were able to successfully create orthoses according to the assignment criteria and were able to reflect on how to improve and modify their orthoses. As such, students demonstrated procedural knowledge development through technical problem solving. Repeated problem solving can result in more efficient results but can be done without the development of conceptual knowledge (Mylopoulos et al., 2018a, 2018b).

In both lab formats, students reported developing conceptual knowledge such as why a client's hand might be red (i.e., material being too hot on contact), however, they were unsure how to choose an orthosis for a client's specific condition, demonstrating incomplete development of conceptual knowledge. The development of conceptual knowledge occurs during active learning activities that promote the synthesis, analysis, and generation of knowledge which exposes students to struggle, risk-taking, and failure (Mylopoulos et al., 2018a). The at-home lab provided a medium for students to engage in active learning, through productive struggle. It enhanced learning and conceptual understanding by pushing students to generate new and flexible solutions in a different environment with limited tools and support. Students reported difficulties during the at-home lab which challenged their experience (e.g., lack of materials and equipment, limited support, and independent preparation). Despite these challenges, students sought out resources within their environment and demonstrated creative problem-solving to successfully complete the task. This at-home lab exposed students to productive struggle where they took risks, failed, synthesized, analyzed, and problem-solved while being resourceful.

Implications for Occupational Therapy Education

Building competence in clinical skills is an important element of occupational therapy education. Students in this study noted the applicability of a hybrid learning approach to the development of other clinical skills, such as prescription of mobility aids, manual patient handling techniques, or home safety assessments.

Clinical skills are often taught in a lab setting, and these skills are further enhanced as students move into a practice setting. An in-university lab opportunity with close guidance is important for students to learn and practice a new skill. Implementing an intermediate step of an at-home lab experience, with less structured guidance and feedback, provides an important opportunity for scaffolded learning, and can build adaptive skills and confidence in preparation for working with clients. Performing clinical skills in an at-home environment prior to entering a practice setting enables students to be self-driven through the challenges of productive struggle, thus scaling towards greater independence as a future clinician.

The intentional scaffolding of learning activities within the adaptive expertise paradigm encourages students to move beyond procedural knowledge related to clinical skills to a deepening of conceptual knowledge. Conceptual knowledge will assist them when they encounter challenging client scenarios during practice.

There are a number of ways in which future hybrid structured labs can further develop conceptual knowledge and make the at-home struggle more productive. Hybrid labs should incorporate approaches such as small group discussions in both lab settings that facilitate dialogue to connect case studies and the orthosis by asking 'why' and 'what if' questions, in order to extend the understanding of clinical reasoning concepts (Mylopoulos et al., 2018a). Such discussions would also provide an opportunity for more immediate feedback to students that foster the integration of adaptive learning. For the struggle to be productive, instructors must provide students with immediate feedback to highlight concepts, introduce questions, reinforce performance, and correct conceptual errors (Mylopoulos et al., 2018a). Providing small group feedback sessions would help students to integrate others' learnings into subsequent at-home labs and enhance independent problem-solving in the at-home environment. Creating an environment where students have the opportunity to learn and develop orthosis fabrication skills by encountering new challenges and providing feedback through the process, may foster the development of further adaptive expertise to enhance occupational therapy practice.

Limitations

The sample size for this study was small and limited to the experience of one cohort at one university. Students received recruitment emails to their university addresses following graduation, which likely limited those who saw the notice and may have led to a lower response. Students were randomly assigned to two different orthoses among multiple options; consequently, the different orthosis types may have impacted learning. Prompting questions for the reflections were not developed for this study and focused more on the technical skills rather than clinical thinking skills. The shift to hybrid learning was a rapid transition that occurred over a 24-hour period. As a result, the hybrid learning experience was not optimally designed for the purposes of this study.

There was a 10 to 13 month time gap between the orthosis fabrication experience and the interviews. Participants' ability to recall specific events, emotions, or details of their experiences can be influenced by this time gap resulting in limitations in the accuracy and completeness of the information provided. Although there was a significant time gap, the reflection papers were used to attempt to bridge this time interval.

The investigators are occupational therapy students who are familiar with the program's orthosis fabrication curriculum as they participated in the hybrid learning experience the following year. As a result, they may have brought an overtly critical or favorable outlook on the curriculum based on their personal experiences. The investigators acknowledged the potential bias and actively reflected throughout the study period to decrease potential bias.

Conclusion

Hybrid learning of orthosis fabrication provided an experiential learning experience that fostered development of new concepts and knowledge in orthosis skills and skills that are transferable to other areas of practice. The adaptive expertise framework helped identify the elements of productive struggle leading to strengthened procedural learning. However, the element of conceptual knowledge ('why and how questions') was limited due to a lack of immediate feedback and guided clinical reasoning, which contributed to perceived feelings of incompetence among students. Future occupational therapy curriculum may benefit from applying a greater emphasis on developing and scaling independence through an experiential learning opportunity to help students build competence and transition into clinical practice.

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