THE UNIVERSITY OF WESTERN AUSTRALIA

Developing a valid and reliable tool to assess competence in fabricating custom hand orthoses: self versus expert assessment

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Bachelor of Science, Occupational Therapy

This thesis is presented in partial fulfillment of the requirements for the degree of Master of Health Professional Education (by coursework and research) of the University of Western Australia - 48 points of the required 72 points.

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Faculty of Health and Medical Sciences

The University of Western Australia

2019

Declaration

I certify that this thesis is my own composition and to the best of my knowledge all sources have been acknowledged. It does not contain any material previously published or written by another person except where due reference is made in the text and my contribution is clearly identified in the thesis. The thesis has been completed during the course of my enrolment in this degree at UWA and has not previously been accepted for a degree at this or any other institution.

[redacted]

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Acknowledgements

This research was supported by an Australian Government Research Training Program (RTP) Scholarship.

I would like to thank all those who assisted me with the process and enabled me to achieve the final product of this thesis:

Firstly, thank you to Sue Miller, my principle supervisor for her incredible knowledge, support and valuable feedback, whom without this could not have been possible. For her prompt, helpful feedback, endless encouragement and gentle nudge to keep going when it mattered most. I sincerely thank her for her time, energy and enthusiasm.

Secondly, to my secondary supervisor, Karen Long whose knowledge and experience in the field of hand therapy and occupational therapy education guided me from the research proposal phase, through to the data collection stage and finally in advising me during the write up of the thesis.

To the experienced and expert hand therapists who dedicated their valuable time to the research process and helped me develop and design an assessment than can now be widely used in clinical and university settings. These include: Alex Retallick, Judith Elliott, Joelene Colliton, Bethanie Trevenen, Emma Staples, Sharyn Kerr, Gabrielle Sibma, Tessa Franklin, Kahli Masini, Judith Wilton and Barbara Hall.

A special thanks to Alex Retallick and Judith Elliott who marked a multitude of students' splints and without their time and dedication, I would not have been able to complete the final data collection phase of my research. Your expertise, advice, reinforcement and persistence helped me every step of the way towards completing my Masters and for that I am very thankful.

To Dave Parsons, who assisted me in obtaining ethics approval from Curtin University and helped coordinate the data collection for this site. His support for the research process was much appreciated.

To all my work colleagues, specifically Sonja De Munck, Jenny Swan and Helen Margaria, who supported me through this journey and for allowing me to take the from work in order to complete the write up of this thesis.

I want to thank my aunt Bette, whose own research journey opened up my mind to the idea of enjoying the process of research. Your passion for work and constant strive to be the best possible educator was a major motivator for me in embarking on this journey. Thank you for your honest advice, assistance and support.

And last but not least, to my dearest family, my husband Jamie, sons Kai and Sam, mum and dad, and my sister Stacey whose unconditional love and encouragement gave me the drive I needed to embark on this journey and complete it to the best of my ability. You believed in me every step of the way and for that I am eternally grateful.

Abstract

Occupational therapists in the field of hand therapy are faced with the challenge of restoring hand function and returning patients to occupational pursuits. The provision of custom hand orthosis fabrication is an integral intervention in optimising upper limb function. Increased importance is being placed on the development of this technical competency and more importantly the ability to test this in a valid and reliable manner.

The purpose of this research study was to develop a valid and reliable orthosis competency assessment, and use this to investigate the relationship between the students' self-rating and the expert assessment of fabricating custom hand orthoses.

The research was a quantitative, descriptive, correlational study. It followed three stages. In the first stage, the researcher developed an orthosis competency assessment. Expert hand therapy clinicians and university lecturers were consulted to increase content and face validity of the assessment. In the second stage, the inter-rater and intra-rater reliability was tested with five assessors. In the final stage, university students studying occupational therapy were recruited to provide a self-made forearm orthosis, corresponding photographs and the completed orthosis assessment. One expert assessor used the competency assessment to mark student photos and the final splint product. The researcher then compared the expert and the self-assessment scores to determine if there was a correlation between these.

An orthosis fabrication competency assessment was developed that showed acceptable inter-rater reliability (k=0.6). Both expert and self-rated scores showed that all students who completed the assessment achieved the minimum score for

competence in each of their splint assessments. The results showed there was a statistically significant difference between student and expert scores, with students more likely to over-rate their performance.

The author of this study designed a valid and reliable orthosis fabrication assessment for use with students and junior occupational therapists in both university and clinical settings. It is recommended that this assessment be used as an expert-rated tool and as a means of teaching the skill of accurate self-assessment. The orthosis competency assessment could potentially be used within a performance development framework in an effort to promote lifelong learning and enhance positive patient outcomes.

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Organisation of the thesis

The thesis comprises six chapters. A description of each chapter is summarised below.

Chapter 1: Introduction. This chapter explains the context of the research study and outlines governance and social issues informing competence. It explains the research aims and questions.

Chapter 2: Literature Review. This chapter reviews the published literature on current psychomotor skill teaching and assessment techniques. A critical analysis of the methods of assessing technical skills is provided. Furthermore, the gaps in literature are highlighted.

Chapter 3: Methodology. This chapter describes the study process and provides rationale for using a quantitative correlational design to investigate the reliability and validity of the orthosis fabrication competency assessment. Population characteristics, data collection and analysis methods are also described.

Chapter 4: Findings. This chapter will describe the results of the data, particularly in regards to measuring the inter-rater reliability and comparing expert and student scores of the assessment tool designed as part of this study.

Chapter 5: Discussion. In this chapter, the findings are discussed with reference to the published literature. The limitations of the study are presented and suggestions for future research are explored.

Chapter 6: Recommendations/Conclusion. The final chapter will discuss the findings of the research and how this will impact future practice in both clinical and university contexts. Recommendations are provided for the implementation of the orthosis competency assessment tool into educational practice. Finally, a summary of the research study will be presented.

1. Chapter One: Introduction

1.1 Introduction

Occupational therapists in the practice area of hand and upper limb rehabilitation are expected to be competent in custom orthosis fabrication. Proficiency in the skill of orthosis fabrication is crucial in reducing negative patient outcomes. Occupational therapists are faced with the challenge of objectively assessing technical competencies, which are taught in both university and clinical settings. In this chapter, the author explores the local regulatory, social and governance issues driving the need for splinting competence and outlines current methods of assessing competence in orthosis fabrication, providing a rationale for and significance of the study. In order for the researcher to provide a thorough understanding of the context, the thesis commences with a background section which explores hand therapy practice within a local context.

1.2 Background

Occupational therapists in the field of hand therapy are faced with the challenge of restoring hand function and returning patients to former meaningful occupational pursuits.[1,2] Upper limb custom orthosis fabrication is an integral intervention in optimising function and is defined as a key skill in the scope of practice for occupational therapists.[1,3] An orthosis is a device that applies an external force to the body for the purpose of immobilisation, protection, correction and prevention of deformity.[2,4,5] It should be noted that orthosis, splint and brace are interchangeable terms[6].

In practice, occupational therapists use low temperature thermoplastic to apply a custom-made splint to a patient's hand. An orthosis can have the function of reducing pain, protection from injury, preventing deformity, improving joint mobility and assisting function.[2]

Orthosis fabrication requires a combination of technical skill and clinical reasoning to ensure optimal patient outcomes. The skill of upper limb orthosis fabrication requires knowledge of upper limb anatomy, tissue pathology, principles of biomechanics and kinesiology, and psychomotor skills of design.[1,2] When fabricating a custom orthosis, it is important to prevent adverse patient outcomes by minimising pressure and preventing ischaemic tissue damage, compromising nerve and vascular systems, pain, and reducing skin integrity.[7] The areas of potential increased pressure are bony prominences and the dorsum of the hand where skin is more fragile, especially in people who are elderly.[1,7] There are many methods of reducing the pressure of a splint when applied to the hand, such as increasing the surface area of the splint, contouring, padding bony prominences, rolling or flaring edges, and increasing the width of Velcro straps.[1,7] In order to optimise patient adherence to splint wearing regimes, splints need to be designed to be comfortable, cosmetically pleasing and meet the occupational performance needs of the patient.[2]

Orthoses that are designed to immobilise one or more joints are considered the basic foundation of design and are taught and practised during the undergraduate and pre-professional education program. More complex mobilisation orthoses, such as those that intend to correct joint deformity, are taught in a clinical setting once competence has been achieved in the fabrication of immobilisation orthoses.

The current study will assess competence in fabricating immobilisation orthoses, which are the essential foundation skills required for overall splinting competence. Therefore, it is essential for students to understand the basic principles of splint design in order to enhance patient outcomes and correctly fabricate an orthosis.

1.3 What are the skills required for orthosis fabrication?

Knowledge of the principles of the biomechanics of design such as minimising pressure, maintaining equilibrium, visual aesthetics and the functional goals of the patient are essential in fabricating effective custom orthoses.[1,7-9] The first principle of minimising pressure reduces the potential for adverse patient outcomes and is incorporated into the splint design, for example, padding bony prominences, ensuring correct contour and using thick straps to reduce the amount of force applied.[1,7-9]. The second principle of maintaining equilibrium ensures all forces are equal, with uniform pressure applied throughout the whole orthosis to prevent shear or friction forces, for example the splint material needs to be strong enough to hold the limb in the correct position.[1,7-9] The third principle of mechanical advantage describes the ability of the orthosis to adequately support the intended joints; for example, when splinting to immobilise the wrist the splint needs to be long enough in the forearm section to be able to support the weight of the hand, which helps to prevent shear forces.[1,8] The final consideration is aesthetics which is important to increase patient compliance, for example, asking the patient to choose a splint colour, and ensuring there are no pen marks or fingerprints left on the splints during the moulding process.[1,3,10]

Once knowledge of these principles is established, the student is required to use psychomotor skills such as template design, handling of the material, cutting the plastic, securing the Velcro, rolling sharp edges, and moulding the splint into the correct position on the patient.[1,7,9] Therefore, achieving competence in splint fabrication requires the integration of knowledge of biomechanical principles of design and the psychomotor skills of splint fabrication.

1.4 Effects of poor hand orthosis fabrication

Occupational therapists design and fabricate upper limb orthoses that provide benefit to patients and minimize adverse outcomes.[1] Poor hand splinting techniques can lead to decreased patient compliance, increase the chances of infection or cause debilitating biomechanical deficits such as joint contractures.[1] The published literature suggests that patients are more likely to be compliant with wearing a splint if it is both comfortable and aesthetically appealing.[1,2] Furthermore, poor orthosis fabrication can cause detrimental patient outcomes including skin breakdown, pain, discomfort, nerve compression, reduced vascular supply, and difficulty donning or doffing.[1] The potentially negative impact of poor custom orthotic fabrication reinforces the need for the development of a reliable and valid competency assessment tool.

1.5 Teaching orthosis fabrication

The technical skills of orthosis fabrication are currently taught formally and informally in both university and clinical settings. Teaching of upper limb orthosis fabrication using low temperature thermoplastics is part of the standard curricula of universities which offer occupational therapy courses in Western Australia. Globally, occupational therapy courses offered at universities obtain credentialing through The World Federation of Occupational Therapy. The Federation specifies 'Minimum Standards for Education' and identifies performance outcomes for graduating occupational therapy students.[11] Occupational therapy students are first taught the principles of orthosis fabrication and design in lectures and tutorials. Thereafter, technical skills are taught in a laboratory setting using techniques such as role modeling, video recordings and practice.[12]Not all occupational therapy students will have the opportunity to be taught or practise making a splint within a clinical setting, therefore, students will graduate with varying skills. The role of the Occupational Therapy Council (Australia and New Zealand) Ltd is to set competency standards whereby education programs are assessed against these through a course accreditation process.[13]

In addition to the teaching of splinting skills in a university setting, The Australian Hand Therapy Association offers courses requiring fees that are available to all occupational therapists to enhance their splinting skills. Those on offer are formal accredited education courses on both immobilisation and mobilisation splinting and the content includes the relevant theory and practice of splinting. Participants are required to complete a formal written assessment in an examination format and submit a written case study justifying their splint choice and critiquing of the splint product.[14]

Conversely in clinical settings, junior occupational therapists and students are taught hand and upper limb splinting during their practical placements through observation, role modeling and practise. In a clinical context, technical splinting skills are taught using the cognitive apprenticeship model of education that offers a staged approach to teaching in order to transition the student or junior therapist from a novice towards competent practise and eventually striving for a highly skilled level of practise.[15,16] The cognitive apprenticeship model and Kolb's experiential learning framework provide clinicians and university lecturers with the key concepts for teaching a technical skill and can be related to the teaching of orthosis fabrication.[17,18] Within these frameworks, learning through practise is essential in effective teaching of a technical skill, initially using modeling, such as demonstrating how to make an orthosis, then progressing to coaching, by providing verbal prompts and finally using the technique of scaffolding where the level of assistance is gradually reduced. These stages aim to progress the student or junior therapist from the level of practice of a beginner toward that of a competent learner.[19] The final three stages of Kolb's model uses articulation, which promotes student discussion on their performance; reflection that allows the student to diagnose their perceived difficulties with making the orthosis and; exploration to help the student to set their own goals and develop independent skills for lifelong learning.[15,20] These final stages promote reflective practice in order to develop skills of independent learning and change in practice based on self-analysis toward becoming an expert.[21]

1.5.1 Competence based education framework

Competency-based education is a new teaching framework where the outcomes are measurable, skill-specific and in line with competency standards set by the World Federation of Occupational Therapy and the Allied Health Practitioners Regulation Agency.[22] The model suggests measuring outcomes of students' performance and ability, rather than their knowledge.[22,23] Competency based education is gaining traction as the preferred model of teaching and learning within a university setting compared to the more traditional, curriculum-assessment based framework.[23,24] Competency assessments focusing on objectively measuring a skill are essential within the competence based education framework to identify whether students show skill proficiency, in order to enhance patient outcomes.[23] Often the methods to effectively assess a student's ability to perform a skill require resources such as time, money and availability of examiners, for example assessments such as: objective structured examinations or direct observation.[22]

1.6 Assessing orthosis fabrication

Orthosis fabrication skills are assessed informally and formally in both university and clinical settings. Currently, Western Australian universities assess splint fabrication skills formally through the use of a marking rubric as well as by student submission of a written critical reflection of their orthosis.[12] Within a clinical context, the technical skills of orthosis fabrication are usually assessed informally during practise sessions or formally within student-supervisor feedback sessions. Often junior therapists and new graduates are placed into the upper limb specialty and expected to function relatively independently within a busy clinical environment. Although there is informal and formal splint education provided, junior therapists may only have a limited number of chances to practise or see a splint being made before being expected to make one for a patient themselves. Currently there is no standardised assessment of splinting competence. There is an argument to support an easy to administer, self-assessment of splinting skills that is introduced at a junior level of training. This has the potential to equip therapists with the ability to identify the areas in which they are performing well, and to identify those that require improvement. This would be especially important in an environment where therapists may be working independently with minimal supervision such as rural and remote regions or busy in clinical environments.

1.7 Reflective practice

Universities and clinicians in Western Australia have provided feedback regarding the clinical readiness for students to enter the workplace and report that while students effectively learn the technical skill of orthosis fabrication, they have not yet mastered the ability to understand the theoretical concepts of their splint design and how this can impact patients in a clinical setting.[12] In other words, the students have a reduced ability to use reflective methods to understand how they can improve their future practice. The skill of self-reflection is essential within Kolb's experiential learning cycle as it enables the learner to identify areas of competence and on the other hand, areas for improvement.[18] The skill of reflection is viewed as essential in order to move towards proficiency and to promote life-long learning.[12,25-27] Self-assessment is an important component of reflective practice thus there is a need for an assessment that is objective, structured and includes essential elements of orthosis fabrication and design that can be used in a university and clinical setting in order to promote reflective learning. Universities in Western Australia currently measure reflective practice by requiring students to submit a reflective self-critique written paper for grading. While it is an effective method of measuring the skill of reflection, it can be time consuming to mark and this method is not appropriate to use in a clinical setting due to the time taken to mark the papers. There is a need for a quick to administer self-assessment of performance that can be used in a university and clinical setting to encourage reflection.

1.8 Competency standards

Competence is defined as an individual's ability to perform a task, skill or behavior.[3,23] It is suggested that competencies can be further sub classified into knowledge, skill, motives, traits and self-concepts.[10] Professional credentialing is the process by which a competence standard is measured against clinical performance, and is able to distinguish between a novice and an expert.[10] The outcome of an American practice analysis of hand therapy in 2003 and 2008, rated orthosis fabrication as a critical skill for proficiency as a hand therapist.[3,28] The World Federation of Occupational Therapists developed minimum standards for the education of occupational therapists globally. The standards specify that occupational therapy graduates are required to demonstrate the ability to fabricate hand and upper limb orthoses.[29] Local national standards such as the Australian Minimum Competency Standards for New Graduate Occupational Therapists, also support and reflect the need for entry-level graduates to demonstrate this technical skill.[11] The competence of American hand therapists is measured through a combination of work experience and a pass mark in a hand therapy certified examination to become a certified hand therapist.[3] Australian hand therapists are able to complete this examination externally, however there are limitations in the application of this to the local workplace. The hand therapy certified examination is limited in that it tests knowledge of theory and clinical reasoning skills, however being a written examination it is unable to establish the examinee's proficiency in technical splinting skills.

In February 2018, The Australian Health Practitioner Regulation Agency released competency standards developed by the Occupational Therapy Board of Australia to provide a framework for clinical skills in practice.[29] Within this framework, the technical skill of splinting is incorporated in standard two, that of knowledge and learning. In this standard it specifies that occupational therapists have a responsibility to reflect on practice, maintain currency of skills and implement a specific learning plan when moving to a new area of practice.[29] Proficiency in the technical skill of orthosis fabrication is specific to the area of hand and upper limb rehabilitation. Developing competence requires an understanding of best practice and implementing reflective learning, especially when a student, new graduate or an experienced occupational therapist commences work in this specialty. Global and local pressures on occupational therapists to identify competence in hand therapy splinting reinforce the need for a valid and reliable assessment of competence of this technical skill.

1.9 Local social and political issues

Practicing health practitioners in Australia are required to adhere to registration standards under the Health Practitioner Regulation National Act.[30,31] Under this Act, occupational therapists are required to undertake continued professional development by showing evidence of knowledge, expertise and competence.[30-32] Regulations stipulated by the Act declare that consumers have the right to expect provision of occupational therapy services in a competent manner within practice standards.[31] The requirement for occupational therapists to develop proficiency standards for fabricating custom-made thermoplastic orthoses is essential in preventing injury to patients and ensuring the best possible therapeutic outcomes.[10,33] As part of annual registration as an occupational therapist, the Australian Health Practitioners Regulatory Agency requests evidence and documentation of commitment to professional development. Furthermore, to be a full member of the Australian Hand Therapy Association, occupational therapists need to provide evidence that they are competent at more than a novice level. Therefore, the need to provide evidence for competence is essential to fulfill registration requirements and ensure safe and effective clinical practice. However, for practising occupational therapists in a clinical area, there are limited ways of demonstrating competence in the specialised technical skill of hand splinting.

Early in 2011, an Australian private health insurance provider indicated that they would only provide a rebate to patients who receive orthoses made by a competent therapist; one who shows evidence of proficiency in custom hand orthoses fabrication. Although occupational therapists have been fabricating hand orthoses for many decades, the insurer requested objective evidence of proficiency in this skill.[6,34] This resulted in the need for therapists to provide evidence to show that they possess the technical skills and are competent in fabricating custom-made orthoses. For these reasons, the rationale for the need to develop proficiency in the skill of hand orthosis fabrication is strengthened.

Assessment of this skill is topical in the current climate of professional credentialing and is necessary to demonstrate evidence for meeting professional competency standards. Currently there is no objective, reliable and valid assessment available to test the technical skill of orthosis fabrication. An outcome of this study was to design a reliable and valid orthosis fabrication competency assessment that could be widely available and free to access, to assess students and junior occupational therapists in university institutions and clinical settings. In addition it is hoped that the tool will increase self-reflection and analysis and could potentially be used within a performance development framework in practice. Finally, the project aims to assist in enhancing patient outcomes by increasing the standard of skills required for orthosis fabrication and encouraging self-regulation of technical skill performance.

1.10 Statement of aims and objectives

The first aim of this study was to develop a reliable and valid competency tool to assess skills in orthosis fabrication at a novice level. The second aim was to investigate whether there is a difference when using the assessment, between student self-rated assessment and expert assessment scores.

1.10.1 Research questions:

In order to focus the research study, the following research questions were formulated.

1. Does the newly developed hand orthosis tool have content, face and construct validity?
2. What is the inter-rater reliability of the hand orthosis assessment tool?
3. How do students assess their performance in the technical skill of orthosis fabrication compared to an expert?
4. If there is a difference between student and expert assessments, are students more likely to over or under estimate performance using the hand orthosis assessment?

1.11 Summary

This chapter provided the background to the current study within an Australian context, providing political, ethical and governance rationale for the significance of the research. The importance of designing and fabricating splints that minimise adverse patient outcomes was explored. An outline of the structure of the thesis was also provided. The next chapter will present a review of the published literature to investigate current assessments of technical skill competence.

2. Chapter Two: Literature Review

2.1 Introduction

In the previous chapter, the background and justification for the significance of the current study within a healthcare and education context was provided. In this chapter, a detailed critique of the current published literature will be described, highlighting the gap in the literature with regards to the availability of an effective summative assessment of orthosis competency. Furthermore, the researcher explores the literature relating to the teaching and assessment of technical skill competence, thereby providing an analysis of the characteristics of effective assessment design.

2.2 Literature review search strategy

An electronic search was performed using The University of Western Australia's Onesearch tool. This provided access to a number of databases including: ProQuest Central, EBSCOhost, CINAHL, PUBMED, Taylor and Francis Online, and ScienceDirect.

Keywords were generated through discussion with colleagues and experts (both clinicians and academics) in the field of upper limb rehabilitation.

The goal was to identify:

1) What is the definition of competence and more specifically, technical skill competence?
2) How are psychomotor skills acquired?
3) What current teaching methods are used to teach technical skills?
4) What are the characteristics of an effective assessment?
5) What are the best methods of assessing a technical skill?
6) What assessments are available for assessing the skill of orthosis fabrication?

The following keywords were used either individually or in combination using Boolean operators e.g. AND / OR:

1. Occupational Therapy	11. Simulation	14. Face/content validity
2. Competency/Competence	12. Reliability	15. Self-assessment
3. Splinting	13. Validity	16. Checklist/s
4. Health professional/s	14. Hand therapy	17. Global rating scale/s
5. Assessment and health	15. Orthosis fabrication	18. Clinical competence
6. Technical skill assessment	16. Competency based education	19. Skill-based assessment
7. Self versus Expert	10. Reflective practice	20. Outcome-based education
8. Competency standards	11. Teaching technical skill	21. Rating scale/s
9. Reflective learning	12. Experiential learning	22. Expert-assessment
10. Objective structured clinical examination (OSCE)	13. Inter-rater reliability	23. Thermoplastic

Table 1: Literature review search terms

In addition to electronic access of journal articles, medical and occupational therapy textbooks were sourced and used to identify the negative effects of poor orthosis fabrication on patient outcomes. Anatomy textbooks were used to identify surface anatomy and inform on the design of the orthosis fabrication assessment. The journal articles were critiqued using a method designed by McMaster University that uses a table to provide headings for analysing quantitative and qualitative research designs.[35,36]

2.3 What is competence?

In order to form a clear perspective on the methods for assessing technical skill competence, it is imperative to understand the definition of competence and how it develops over time. Competency can be defined as an individual's ability to effectively perform a job, skill or behaviour and can be categorised into self-concept, knowledge and skills.[10,37] It is believed that knowledge and skill capabilities can be modified through training, however the self-concept (a student's perceived competence) is an element of awareness that develops over time and is more difficult to teach.[10,38] Competence within a profession has been assigned by Bloom's taxonomy into three domains; -that of cognitive, affective and psychomotor skill, and is described as operating on a continuum of practise.[39-44] It is well documented in the health professions education literature that a continuum exists when developing a technical skill, from being a novice toward achieving competence and finally becoming an expert.[40,45]

2.3.1 Technical skill competency

Technical skill competence is described as "the minimum standard to safely perform a procedure or task independently".[46p.1050] It is context specific, that is, the ability to perform a skill in one scenario does not necessarily predict skill competence in a different setting or with another patient group.[47] A psychomotor skill is developed through the interplay between the cognitive processes, such as an understanding of the underlying knowledge and principles, and the motor functions such as the development of fine and gross motor skills.[43] Psychomotor skill proficiency develops with deliberate practice and through receiving feedback on performance.[43] The achievement of proficiency in orthosis fabrication requires a knowledge of the musculoskeletal principles underpinning this skill and the psychomotor processes to perform the skill correctly.[48]

2.3.1.1 Psychomotor skill acquisition

The published literature reports on a variety of models that provide a framework for the acquisition of motor skills. The models of skill acquisition proposed by Dreyfus and Dreyfus[49,50] and Fitts and Posner[43,51] will be described in the following paragraphs in order to provide an explanation of how a motor skills develop over time.

Dreyfus and Dreyfus[49,50] proposed a five-stage model of technical skill acquisition that explains how students' progress from a novice towards being proficient (Table 2). In the first stage, students commence at a novice level of practice, requiring close supervision. After this, the novice progresses to an advanced beginner, who is able to achieve some steps of the task independently. Next, the learner moves toward being competent in their ability to perform a simple task with no supervision. From a competent level of practice, the learner moves towards a level of proficiency, whereby their skills can be applied to different scenarios. Finally, the model describes that once the first four stages have been achieved, the learner becomes an expert who is able to combine experience, knowledge and creativity and apply these skills to a variety of scenarios.[49]

Skill level	Components	Perspective	Decision	Commitment
1. Novice	Context free	None	Analytic	Detached
2. Advanced beginner	Context free and situational	None	Analytic	Detached
3. Component	Context free and situational	Chosen	Analytic	Detached understanding and deciding; involved outcome
4. Proficient	Context free and situational	Experienced	Analytic	Involved understanding; detached deciding
5. Expert	Context free and situational	Experienced	Intuitive	Involved

Table 2: Dreyfus' five stage model of skill acquisition [49p.181]

The model designed by Dreyfus can be used to explain the development of the skill of fabricating a thermoplastic splint. The novice requires step by step instruction, the competent practitioner can independently replicate a previously demonstrated splint and the expert can create new splint designs based on individual patient needs.[10,49] Knowledge of the different stages of skill acquisition is crucial when applying various teaching methods, in order for the educator to tailor these to the appropriate stage of the learner.

Fitts and Posner[43,51] proposed a three stage model for technical skill acquisition, consisting of cognitive, associative and autonomous domains.[52] They stated that initially in the cognitive phase, the learner develops a mental picture of how the task is performed. The second stage, the associative domain, describes the learner as practicing the motor skill and integrating this with the cognition of how the task is performed. In this stage, the learner still requires instruction and feedback on their performance. The final stage describes the learner as being able to automatically perform a task, based on practice and feedback.[51,52] In order to promote success in learning a technical skill, the skilled behavior must be goal directed, provide opportunity for deliberate practice, integrate knowledge with motor skill and provide opportunity for feedback to enhance performance.[51,53,54] An advanced understanding of the skilled behavior is essential in order to promote learning. Deliberate practice refers to the repetitive and structured method of improving the performance of a manual skill.[54] In order for deliberate practice to be an effective method of achieving mastery of technical skills, the educator must combine knowledge, demonstration and feedback in order for the student to improve their practice with each repetition of the task.[54] The literature suggests that deliberate practice is more effective when the student receives appropriate and timely feedback on their performance.[55] Therefore, the availability of valid and reliable performance-based assessments are necessary in order to determine the effectiveness of deliberate practice as a teaching method for improving manual skills within a university and clinical context.[55]

2.3.2 Effective technical skill teaching methods

Technical skills are taught at a university level and in clinical settings. The challenge often encountered at a university level, is to train students to be capable of applying their skills to real-life scenarios. There are often barriers that limit the teachers' ability to train students to be competent in applying their skills to real life scenarios. These include factors such as financial restrictions, time constraints and concern for patient safety. Teachers and clinicians are faced with the task of mentoring students from being a novice to eventually coaching them to becoming experts.[56] The surgical and medical literature further highlights the difficulty faced by clinical supervisors and university lecturers in safely and effectively training medical students to perform surgical procedures.[57-59] A surgical procedure is a high stakes skill and can have negative consequences if a novice performs the procedure on a patient. The challenge of how to teach a technical skill that students can then translate into a real-life environment is an issue extensively discussed in the medical and surgical literature.[20,40,57-60] Similarly, the technical skill of orthosis fabrication, although a skill that is of lower risk of injury compared to surgery, is difficult to teach in a real-life environment due to the risks of patient injury and therefore it is often practiced on peers.

2.3.2.1 Experiential learning theory

Teachers and clinical supervisors currently use experiential learning theory and adult learning principles to provide a framework for teaching technical skills.[56,61] This theory, described by Kolb[17,18], suggests that adults are active learners and learn best through involvement and practice, integrating former experience with current concepts and knowledge.[62] Therefore, the notion supports lifelong learning through integration of theoretical principles with skill practise. See Figure 1 (p.33) for a diagrammatic representation of Kolb's experiential learning cycle.

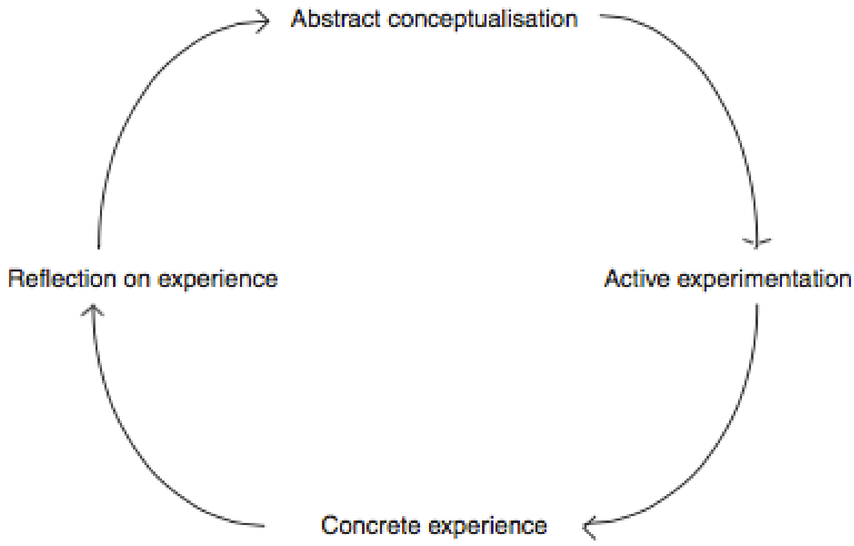

Figure 1: Kolb's experiential learning cycle adapted from Glanville et al[63]

Within a clinical and university setting, technical skills are taught using experiential learning techniques such as simulation, role-play, group discussion and skill practice exercises that promote active rather than passive adult learning.[17] The published literature reports that experiential learning is more beneficial than the traditional didactic lecture style of teaching in its ability to enhance students' self-awareness, confidence, self-efficacy, and motivation for further learning.[17,41,61] Kolb, in his experiential learning theory, suggests that initially students should be exposed to concrete experience and then have opportunities for reflective observation.[17,18,61]

Previous studies recommend that students and newly graduated health professionals need to develop baseline skills as a prerequisite for moving toward competence in the field of hand therapy.[1-3] Universities in Western Australia teach orthosis fabrication in small group practice laboratories where the students are able to apply the skill through concrete experience. The students then submit a critical reflection, thereby encouraging the skill of reflective observation. Kolb's theory goes on to explain that advanced practitioners build on these skills by forming ideas and concepts, as well as being involved in active experimentation based on unique clinical situations.[17,62] Often these more advanced techniques are taught and practised within clinical settings once baseline competence is established. In order to teach the skill of orthosis fabrication, universities in Western Australia currently use didactic lectures to reinforce knowledge concepts and then implement techniques, such as role modeling and skill training exercises in order to apply the theoretical concepts in practice.

The current methods for teaching orthosis fabrication can be problematic, as students practice these skills on a non-pathological hand (often those of their peers) and do not have opportunity to practice constructing orthoses for patients who have pathological abnormalities. Stefanovich et al[64] propose that simulation can provide students with the opportunity to enhance their practical skills and therefore be more competent when treating patients in clinical contexts. Simulation has become the gold standard for teaching technical skills in the fields of medicine, such as training in surgical procedures, and in nursing, such as basic life support training.[65-67] However, the effectiveness of simulation and a description of its use as a training tool in the occupational therapy curriculum has not been well documented to date.

2.3.2.2 Simulation

Simulation as a teaching technique is used extensively in training surgical and medical students and has become increasingly used in nursing and the health professions as a method of teaching technical skills by mimicking real-life situations.[40,48,59,64,65] This strategy enables a real-life clinical scenario to be practiced in a safe environment through the use of a virtual reality simulator or a 'dummy' model.[68] Simulation is a beneficial adult teaching tool as it allows active participation and provides immediate feedback to the participant either through self-reflection or peer evaluation.[66,68,69] Furthermore, it also allows the participant to apply theory to practice in an environment that mimics real clinical scenarios. The published research literature also suggests that simulation directly improves participant satisfaction with learning.[69]

Although simulation has been considered as an effective method for developing technical skills, students have reported anxiety related to this method of teaching.[70] Psychology theories suggest that students' who experience feelings of anxiety have a reduced ability to retain knowledge during a learning task, have reduced success and are more prone to performance errors.[71] Furthermore, the psychology literature reports that there is an association between levels of anxiety and the students' fears of failure which can lead to reduced performance.[71] The participant satisfaction with the use of simulation as a teaching tool is not known within the context of hand therapy education.

The use of simulation has not yet been used in Western Australia universities to instruct students in the skill of splint fabrication. Although viewed as a gold standard of teaching in fields such as nursing, medicine and dentistry, the impact of simulation on the learning curve of students in achieving competence in orthosis fabrication is not known. Prior to introducing new methods of teaching, it is essential for the health science educators to have a valid and reliable assessment of technical skill competence in order to identify the impact of these teaching strategies on the students' ability to achieve competence. The current study aims to develop a valid and reliable assessment of competence in orthosis fabrication, in order to measure whether the introduction of new teaching techniques such as simulation, are effective.

2.3.2.3 Proficiency-based training

The literature reports on a variety of pedagogical approaches for effectively teaching technical skills. The surgical literature describes time-based, repetition-based and proficiency-based training techniques.[72] The philosophy underpinning the time-based approach hypothesises that the student must be allowed a sufficient amount of time in order to develop the skills required to effectively complete a given task. The repetition-based methodology is based on providing the student with opportunities for repetition of a given task in order to promote mastery.[72] A potential disadvantage of the time and repetition-based pedagogical approaches is that the teaching of the skill is not tailored to the individual. In other words, some students may require less repetition to achieve proficiency, while others may require more time to conceptualise the requirements of the task.

A proficiency-based training program has been described by education and medical literature as an alternative method to developing motor skill competency.[72] This framework promotes an individualised approach to teaching, whereby a student practices the skill for the amount of time and/or number of repetitions required for them to achieve proficiency, based on pre-established criteria. The criteria are developed by using a detailed task analysis to understand the cognitive and motor requirements of a technical skill.[53,73] Task analysis involves dividing the task into measurable components to assess the subsets of the skill.[52] Within the proficiency-based framework for teaching a technical skill, a detailed assessment rubric is essential to effectively measure technical skill competence. The assessment must be designed to include the subset components of the task, thereby deconstructing the task into measureable components. The researcher developed the orthosis competency assessment by observing an expert while performing the task of making a splint, in order to identify the subset skill components of the motor skill required for orthosis fabrication.

Despite the potential disadvantages of the various teaching methodologies, what they all have in common is that they provide the student with opportunities for deliberate practice and encourage feedback on student performance, at different stages in the learning cycle. Feedback can be provided informally, through clinical and case discussions, or formally using an objective competency assessment tool.[21,74]

2.4 Assessing competence

In order to understand how the competence of a technical skill is assessed, it is firstly important to understand the characteristics of an effective assessment. Secondly, it is necessary to know the effective methods of how to develop a valid and reliable assessment tool. Finally, the educator must select the correct method of assessing the technical skills within the appropriate performance domains, taking into account the learning objectives.

2.4.1 Characteristics of an effective assessment (validity and reliability)

This section provides an overview of the psychometric properties of educational measurement tools. It is well documented in the literature that for an assessment tool to be effective, it should be clear, concise, cost effective, valid and reliable.[40,56,75] A test is valid if it measures what it is designed to measure.[61,75] There are a multitude of methods to measure the validity of an assessment. Construct validity describes the ability of a test to discriminate between levels of expertise, while content validity informs us whether the assessment collects all the required information.[76] Concurrent validity compares the assessment with a gold standard. Furthermore, face validity determines whether the assessment measures a real life situation, while predictive validity identifies the extent to which an assessment can predict future performance.[56,75] To enhance the validity, an assessment must reflect the students' learning objectives, be based on current knowledge and be able to be applied to real-life scenarios.[77]

An effective assessment not only needs to be valid but also reliable. Reliability measures the consistency of an assessment between multiple raters or between different periods in time.[78] The more objective an assessment is, the higher the consistency between raters.[56,59,75,77] When developing an assessment tool it is essential to increase objectivity by using specific, measurable and outcome-based marking criteria.

In order to accurately assess performance of a technical skill, there needs to be an assessment that is valid and reliable. Similarly, in order to effectively evaluate the technical skill of orthosis fabrication, the procedural steps in the motor skill need to be deconstructed and divided into measurable areas of performance.[52] This allows for standardisation of the expectations of the task of making an orthosis.[52] Once the essential skills of performing the task have been identified, they need to be translated into a valid and reliable assessment. This was the process the researcher used to develop the orthosis fabrication assessment.

2.4.2 Developing a valid competency assessment

Health science and education literature documents many methods of developing a valid assessment of technical skills either by using the Delphi technique, consulting with experts in the field, or by using a combined approach.

2.4.2.1 The Delphi method

The Delphi technique is a widely accepted method of designing an assessment tool by using consensus of expert feedback to identify the appropriate content.[79,80] The Delphi process consists of four rounds of consultation and begins with an open-ended questionnaire sent to experts in the field.[79] In the second round, a questionnaire with a ranking scale is sent to the experts for comment, where they are asked to rate the importance of each topic, identified by the researcher from the first round.[79] The third round consists of sending experts the ranking scale and open ended questions and encourages them to justify their ranking decision.[79] The fourth and final round further attempts to develop consensus between experts by asking them to review and revise their ranking of importance of each topic in the assessment.[79] Although the Delphi process is an effective method of validating an assessment, it is time consuming for the researcher to analyse and for the experts to complete, resulting in a high drop-out rate.[79,81] Furthermore, use of the Delphi technique requires the researcher to be skilled and trained appropriately in order to design a valid assessment.[73,79] Therefore, an alternative technique was considered for the development of the orthosis fabrication assessment used in this study.

2.4.2.2 Expert consultation

An alternative method of designing a valid competency assessment tool is to consult with 'experts' in the field in order to increase the content validity.[82] The experts who can be consulted to provide feedback on the content and structure of an assessment include university teachers, clinicians, health care advisors and researchers.[83] Expert opinion is based on clinical experience, knowledge of the specific requirements of a skill, understanding the learning objectives and awareness of the task outcome and competent performance.

Consulting with experts in the field in order to design a valid assessment is an appropriate method of increasing content validity. In a study by Lee et al.[12], a rubric was designed to identify the learning outcomes for an orthosis assessment by using a panel of five experts. Although the assessment tool was reported to have content validity, it had limited sensitivity to identify the difference between a novice and expert due to the binary (yes/no) marking system and lack of objective markers within a scale.[12] However, authors from other journal articles suggest that expert opinion alone may not be enough to ensure content validity and propose using a combined approach.[84]

2.4.2.3 Combined approach

Researchers who are attempting to design a valid and reliable assessment can use a combined approach by consulting with experts and adapting a previously devised valid and reliable assessment, to improve the content validity. For example, in 2013 Fang et al.[83] designed a valid and reliable assessment to measure performance in counseling using a combined approach. The researchers designed the assessment by adapting a previously published valid and reliable objective structured clinical examination and then consulted with experts in the field of social work, mental health workers, researchers and students.[83] Similarly, in a research study by Doyle et al[85], the researchers adapted a previously developed objective structured examination to design a global rating scale as a summative assessment of the surgical skills of seven trainees, evaluating 32 procedures. The final global rating scale showed excellent inter-rater reliability ($r>0.8$) and the data revealed a strong correlation ($r=0.9$) between the mean score and level of experience of the trainee.[85]

In another study, the framework for instrument development described by Devellis[68] was used as a guide for improving the content and face validity of an assessment. The seven step instrument development procedure was implemented by Farra et al[68] in their study in which they designed an assessment of nursing performance in the skill of decontamination. The first stage identified the purpose of the assessment and the second stage generated items for the measurement scale by reviewing the literature. In the third stage, experts were consulted and the authors revised the tool accordingly. The fourth stage piloted the assessment and the final stage used the assessment with their study population ($n=140$).[68] The results of the final instrument showed a high

Content Validity Index score (CVI=0.94) and a high level of inter-rater reliability (r=0.9).[68]

The study described above highlighted the usefulness of the Devellis' framework for instrument development as an effective method of designing a reliable and valid assessment. Therefore, the published literature supports the use of expert consultation and adaptation of other assessments as well as the use of a development framework in order to design a valid assessment of technical skill competence. In the current study content validity was increased using a combined methods approach such as those described above, where the researcher developed the assessment of orthosis competence by adapting an already valid assessment and also consulting with experts in the field of hand therapy.

2.4.3 Assessing technical skill competence

The health education literature documents a variety of theories for technical skill acquisition and assessment.[52,86] The assessment of psychomotor skills has been proposed in a framework by Miller[87,88] who used a pyramid to describe the baseline skills required to measure competence (Figure 2; page 43).

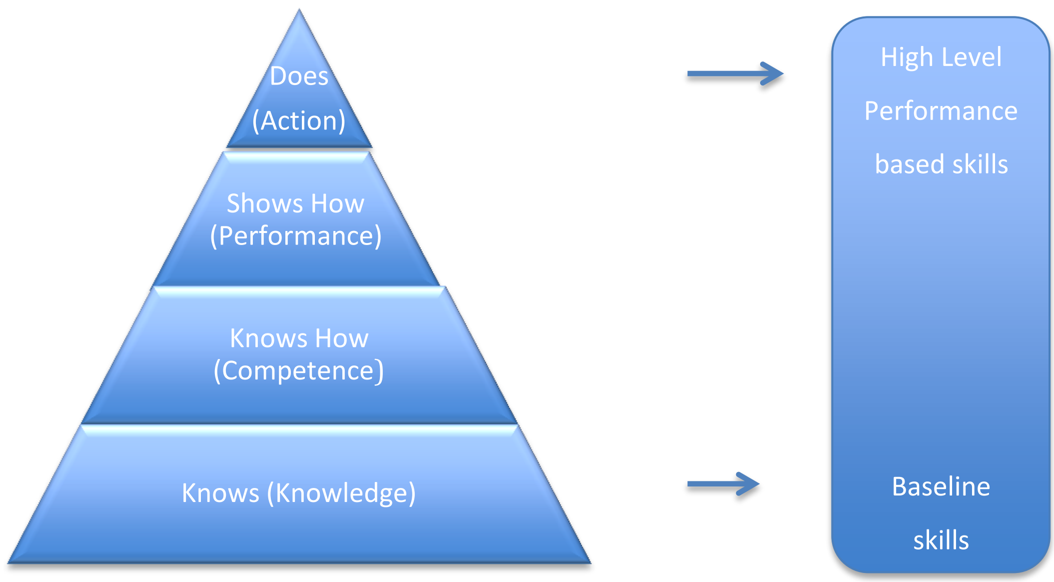

Figure 2: Miller's pyramid of skill acquisition. Adapted from Downing et al[89]

Miller[88] explains that a technical skill must firstly measure the knowledge of the learner based on basic principles underpinning the task, such as anatomy and biomechanics. Secondly, the learner must be assessed on the knowledge of how to perform a task, progressing to the third stage where the learner must demonstrate performance of the skill. Finally, the skill must be measured based on whether it can be successfully applied to real life contexts.[86] The third and fourth stages are measuring performance-based skills and therefore these stages can be applied to designing assessments that measure technical skills.[88,89] Miller's pyramid can be applied to the assessment of competence in hand splinting. For example, written examinations may be used to assess the biomechanical and anatomical principles of orthosis fabrication (the lower levels of Miller's pyramid), while direct observation and use of global rating scales are appropriate methods of assessing the performance of splint fabrication (the upper levels of Miller's pyramid). The current study designed an assessment of competence in orthosis fabrication to measure the upper levels of Miller's pyramid, based on the students' performance and action.

Technical skill proficiency is difficult to assess due to differing expectations between clinical experts and university institutions.[46] There is also limited agreement among the experts regarding minimum performance standards required in order to meet a baseline level of competence.[90] Often technical skills are not able to be assessed safely in real-life clinical scenarios and therefore they are judged in simulated environments either by using such practices as role play or virtual reality scenarios.[46] A further difficulty lies in the development of an assessment of technical skill competence that can be generalised and is not specific to one particular skill set.[46,90]

The literature goes on to suggest that skill proficiency is fostered through receiving objective feedback and implies that receiving feedback should also form part of the assessment.[47,91] In order to provide an explicit opportunity for students to further develop their self-judgement skills in upper limb splinting by providing feedback on performance, the researcher returned the students' self-assessments together with the expert assessment of their performance at the completion of the research study. The intention was to provide the students with an opportunity to improve their future performance by reflecting on their past achievements and limitations.[92]

2.4.4 Benchmarking performance standards

Considering the definition of technical skill competence as the minimum requirement to safely perform a task or procedure, it is necessary to identify the baseline score for achieving competence of these skills.[90,93,94] The education and medical literature recommends that when developing an assessment, the researcher must use a valid methodology to attain a minimum competent score.[90,94] There is currently no published 'gold standard' method of establishing benchmarks for minimum competence and the literature reports that the various methods can produce different passing scores.[93,94]

The minimum competence standard of an assessment can be developed validly, using norm- or criterion-based methodology. The norm-based methods compare the performance results between two or more student groups, to achieve a minimum pass score.[93] This benchmarking methodology is resource-intensive and relies on a history of previous students taking the same assessment under the same conditions, in order to standardise the results and set predetermined performance standards.[93]

An alternative method of setting minimum performance standards is by using criterion-based processes, where baseline performance is set using a predetermined value, regardless of the performance of previous students.[93] The education literature documents a variety of valid procedures for the development of criterion-based performance standards. One such standard setting method is the Angoff method, which describes the process of consulting with 'experts' in the field to reach a consensus.[93,94] The experts score the importance of each sub-skill within the task to determine the baseline level of skill to safely perform a task.[90,93] The scores are then totaled and averaged to determine the minimum cut-off score for competence. The researcher in this study used this form of methodology to develop a minimum 'pass' mark, in order to establish whether the student has achieved competence in the skill of splint fabrication.

2.4.5 Current technical skill assessments

Assessments of technical skill can be classified as formative or summative. The former provides ongoing feedback, whereas the latter describes an overall measurement of skill.[86] When designing an assessment it is necessary to first identify whether the assessment is formative – assessing using a procedural based checklist; or summative – using a global rating scale to assess overall performance.[86] The authors of previous studies document a variety of tools to assess competence of a technical skill in the disciplines of health professions. These assessments include the use of objective structured assessment of clinical skill examination, checklists, global rating scales, rubrics and self-rated questionnaires.[46] These will be discussed in the following paragraphs.

2.4.5.1 Objective structured clinical examinations

Objective structured assessment of clinical skill examination is reported to be the 'gold standard' of assessment in the medical literature as it has a high level of inter-rater reliability and objectivity.[85,95,96] These clinical examinations are more commonly used in university settings. They comprise of a number of stations consisting of a variety of case studies, used to assess different technical skills.[96] The skills are assessed using a predetermined checklist or global rating scale. Objective structured examinations are more suited to a controlled university environment. They are expensive in terms of resources required and are therefore not suitable to be reproduced within the context of a busy clinical environment.[59,74,96]

2.4.5.2 Checklists, Rubrics and Global rating scales

Studies in medicine and surgery report the use of checklists, global rating scales and rubrics as effective objective assessment tools. These are discussed below.

2.4.5.2.1 Checklists

Checklists are task specific, measure whether or not a skill has been achieved, and have been used as objective measures in assessing technical skills.[67] Although they offer objectivity and reliability, the checklists are limited in their ability to discriminate between the novice and the expert.[67,96] Furthermore, they are process-driven and are best conducted in real-time or through video recording, so that the assessor can accurately mark the achievement of each step.[97] The checklist is beneficial for observed behaviours and provides information on process of the skill, requiring a detailed task analysis of the psychomotor skill.[97]

2.4.5.2.2 Global rating scales

Global rating scales measure overall performance and assess generic skills applied to wide variety of clinical scenarios, most commonly using a five-point rating scale.[59,96-98] These scales have been documented as effective in measuring the end product and can be used to distinguish between a novice and an expert.[65,97] While studies suggest combining checklists and global rating scales to offer a more reliable and valid tool to assess surgical skills, other studies have found high reliability and validity when using global rating scales alone.[59,96,98,99] Furthermore, the published studies in the medical and health professional literature that combined a global rating scale and checklist either in a real-time or after by videotaping, had a limited number of participants (ranging from 2-23).[40,46,59,64,96,99]

2.4.5.2.3 Rubrics

Rubrics are a commonly used as an assessment method in higher education that are used to measure a student's performance.[100] Ideally, they need to have three essential elements – specific evaluation criteria, quality definitions and a scoring system.[101] For rubrics to be valid, they must include a detailed explanation of what a student needs to do to competently perform a task.[100] Rubrics should contain guidelines for baseline performance of a skill, with specific and measurable marking criteria, and the scoring system must distinguish between different levels of student performance.[100,101] This method of assessment is used both by educators to assess student performance and by students to inform them on the requirements and expectations of a task.[100,101]

The published education literature reports on the many benefits of using rubrics as an assessment tool. There have been studies that suggest high levels of student satisfaction and perceptions of fairness in relation to marking assignments, with the use of rubrics as an assessment and teaching tool.[101-104] In the aforementioned studies, a rubric was used as both an assessment and instructional tool, however student satisfaction increased when a rubric was provided to them prior to completing the assessment. The use of rubrics as an instructional method to inform students of the task expectations has gained popularity since the implementation of outcomes-based and competency-based education frameworks.[105] Other published studies describe a link between the use of rubrics as an instructional tool and improved academic performance.[101,106,107] In all instances, the rubrics were used to inform the students about the expectations of their performance. In addition, training was provided to these students on the effective use of each rubric. In some cases, the rubrics were co-developed with the students.[107] This is seen as beneficial as students became actively engaged in the assessment process and this lead to an improved level of performance as the students had a greater understanding of the requirements of a task.[108]

There are a limited number of published studies that report on the reliability and validity of rubrics used in assessment of performance. It is important to measure the reliability of a rubric in order to ensure students' grades are consistent between multiple raters.[108] There are mixed reports on whether rubrics have high inter- and intra-rater reliability. In a study by Dunbar et al., a high inter-rater reliability was reported when two raters used a rubric to grade student performance in oral presentation in an education course.[109] Conversely, in a study conducted by Oakleaf, a low consistency in scores between multiple raters was reported with the use of a rubric to assess information literacy skills.[105] The authors recommended that by improving the training of raters on the use of rubrics, the consistency between rater scores could be strengthened.[105] Despite the inconsistent reporting on the reliability of rubrics, the benefits to teachers in being able to objectively and accurately measure performance, and to students who can use the tool to inform learning are clear. Their reliability lies in providing both teachers and students adequate information and/or training in the use of this method of assessment.

Rubrics are designed by using a task analysis to identify the necessary skill requirements, identifying the learning outcomes and reflecting these in the measurement of outcomes within the scale, and developing a clear definition of the score for achievement of each skill subset.[100] In order to enhance the validity of a rubric, the developer should consult with educators and directly observe the task, in order to accurately design an objective measurement tool.[100,101] The author of this study used this methodology in the development of the orthosis competency assessment in order to design a valid rubric.

The development of an assessment tool requires consideration of the benefits and limitations of the various methods of measurement. Checklists require real-time observation of the skill process by either the use of an expert observer or by videotaping. The latter process can be a more time-consuming and costly method of psychomotor skill assessment. Rubrics are documented to be beneficial for both teachers and students in the learning process, while global rating scales have been found to be effective in assessing the product or overall accomplishment of a technical skill. There is a consensus in the published literature that rubrics are best implemented as a combined assessment tool as well as an instructional method to inform student learning. Therefore, rubrics are an effective method of assessing a student's competence in the performance of a psychomotor skill and was the method implemented in this study to assess splinting competence.

Currently, there are no published global rating scales or rubrics found in searching the databases for the assessment of generic splinting skills. Therefore, there is a need for an assessment of global splinting skills that is quick to administer and cost efficient, especially for use in a demanding clinical environment and within a university setting. For these reasons, the author of the current study developed and tested a summative assessment of the proficiency in immobilisation splinting, using a rubric as the assessment method.

2.4.5.3 Self versus expert assessment

Once the appropriate method of assessment to accurately identify the level of skill is selected, it is important to establish whether this will be marked by an expert or implemented as a self-assessment. The published literature documents the benefits and disadvantages for self and expert assessment. These will be discussed in the following paragraphs.

2.4.5.3.1.1 Self assessment: reflection

The research literature suggests that students who are more able to think critically and identify their strengths, weaknesses and areas for change, are more prepared for the requirements of clinical practice.[22,110,111] Furthermore, the development of critical thinking and self-analysis skills are important, in enabling clinicians to be adaptable in different scenarios.[56] The literature suggests that accurate self assessment and personal reflection are necessary skills to have, in order for the learner to modify their attitudes and behaviours.[26] The healthcare environment is constantly changing and patients within a clinical environment have unique needs, therefore it is necessary for a clinician to be a critical thinker, reflect on their current skill level and integrate this with previous experience.[41] Skills of reflection can be encouraged and enhanced formally through feedback sessions and self-reflective assessments.[111]

2.4.5.3.1.2 Metacognition

Within a learning environment and clinical context, students are expected to accurately perform a given task, and to be able to correctly recognise their achievements and errors. Ideally, students need to demonstrate metacognition.[112] This term refers to the ability of knowing how one is performing by having an insight into self-performance compared to the requirements of the skill.[113] In other words, students need to be able to correctly reflect on their learning. The findings in the literature postulates that the skill of accurately identifying one's own strengths and limitations in performance is a prerequisite for effective self-reflection.[114] The studies suggest that metacognition is an important skill in itself that requires development in order to improve accurate student self-evaluation and self-regulation.[43] There are conflicting opinions by authors on how the skill of metacognition is developed. Some studies have reported that metacognition develops naturally over time, as the student becomes more experienced and confident in their practice.[92] Other studies report that the skill of metacognition is developed by being provided with explicit opportunities for deliberate practice of a psychomotor skill and by being given appropriate and timely feedback on their performance.[43,72]

The authors of studies published in the literature recommend that training institutions include teaching the students metacognitive skills within the current curriculum, in order to enable students to improve on their accuracy of self-assessment.[43,92] The development of the skill of accurate self-assessment is rarely evident in university curricula and the research on this topic suggests that students need to be provided with explicit opportunities to develop this skill.[92] The capacity for accurate self-analysis is an important skill in being able to recognise areas of success compared to those that require improvement, and knowing when to ask for assistance.[92] This is a crucial skill to possess when entering the workforce, where new graduates are often placed in positions that offer minimal opportunities for clinical supervision.

The process of self-assessment is an important measurement tool for ensuring improved patient outcomes as it aims to improve self-awareness by encouraging the learner to identify gaps in their own knowledge and skills.[115] Being able to reflect on one's own performance has also been identified as a critical skill for future learning by creating autonomous learners.[57,116,117] Accurate self-assessment can potentially improve patient outcomes and conversely lack of awareness of self-performance can lead to negative patient outcomes.[57,116] Furthermore, self-evaluation has been documented as beneficial in improving self-awareness, motivation and enhancing professional development.[39] Self-assessment, if performed correctly, enables the student or clinician to identify their own strengths and weaknesses and use this information to change future practice.[77,118]

Although the benefits of self-assessment are well documented in the literature, the studies are inconclusive as to whether the students or trainees are able to accurately rate their performance. While self-rating of performance is an important skill to enable lifelong learning, previous studies in the surgical and education literature suggest that students and trainees have limited ability to self-assess compared to an expert.[113,117,118] The educational psychology literature report on this well documented phenomenon, known as the Kruger-Dunning effect.[113,114] The theory suggests that the students who perform in the lower percentile tend to overestimate their performance when compared to an expert.[92,113] Conversely, the students who are in the top percentile are able to more accurately calibrate their performance.[92,113] Furthermore, experts in their field have the tendency to under-estimate their performance.[92,113] The Kruger-Dunning theory suggests that the lower-ranked students lack both the content knowledge and the metacognitive skills to enable them to identify their limitations in performance.[113,114] The Kruger-Dunning effect was assessed in the current study in order to determine whether the same concept is applicable to the field of hand and upper limb competency assessment.

The published education literature suggests methods for improving a student's metacognitive skills, specifically through providing effective feedback on performance. Sadler[119] identified three prerequisites for providing effective feedback. The first stage is having knowledge of the task requirements; that is, being able to deconstruct the task into measurable criteria. The second stage is comparing the standards of the task to one's own performance using a suitable assessment tool. The third stage involves making changes to align performance with the task requirements.[92,119] In all three stages of the feedback cycle, it is essential to have a standardised method of assessing performance. This enables the learner to gain insight into the requirements of the task and also provides the experts with standardised criteria for measurement of a skill. Therefore, in order for feedback to be a successful method of improving self-awareness of performance, there should be a reliable and valid competency assessment that includes task-specific criteria and standards.

Currently, there is no published literature when searching the databases documenting occupational therapy students' ability to self-assess their performance specifically in fabricating a hand orthosis. The researcher in the current study designed an assessment of orthosis fabrication that included collecting the students' self-assessment of performance and analysed the data to identify whether the students were able to accurately self-assess when compared to that of an expert.

2.4.5.3.1.3 Self versus expert assessment

Researchers in the medical and surgical literature have postulated that self-assessment alone is not a sufficient reflection of actual performance and recommend a comparison between self and expert assessment be made. The authors of these studies report that self-assessment alone can lead to under-rating of performance due to a lack of confidence or over-rating of perceived ability due to unconscious incompetence.[47,113,120]

In 2008, Pandey et al[118] conducted a study measuring vascular surgical skills of 42 trainees and found no correlation between expert and student scores (r=0.04), with the mean difference in scores being statistically significant (mean difference=2.9).[118] They also found that participants were more likely to overestimate their performance compared to the experts.[118] In 1989, Falchikov et al[117] conducted a meta-analysis of 44 higher education research studies and found a low correlation (r=0.39) between the student and expert scores.[117] More recently, Blanch-Hartigan[121] conducted a meta-analysis of 35 published articles regarding the self-assessment capacity of medical students and found a low correlation (r=0.21) between student and expert scores. In addition to analysing the correlation between the expert and student scores, Blanch-Hartigan analysed the direction of the difference between the scores and found no conclusive trend as to whether students were more likely to over or under estimate their performance.[121]

In contrast,, in 2011 Arora et al[57] conducted a study of 25 surgeons comparing the self-rating of their performance in laparoscopic cholecystectomy surgery compared to the performance ratings of two experts.[57] The study found strong correlations between self and expert scores, and this correlation was higher with the more experienced surgeons.[57] They also found a trend where more experienced surgeons were more likely to have under-estimated their performance compared to their more junior counterparts. Similarly, a study by Lee et al[12] showed that students who achieved higher grades were more accurate self-assessors.[12] Therefore, the research literature suggests that students or trainees are more likely to accurately self- assess, if they have had more experience or better overall grades compared to their peers.[12,111]

The discrepancy between the aforementioned studies reporting over- compared to under-estimation of performance, may be attributed to the level of experience of trainees or due to the lack of students' understanding of the learning outcomes.[57,113,121] Understanding the direction of inaccuracy between self and expert scores can help in the preparation of training programs and provide insight into the type of skills that need further development.[113,121] Blanch-Hartigan (2011) postulated that students who over-estimate performance may be unaware of their limitations while those that under-estimate may lack confidence.[121] In a clinical environment, under- or over-estimation of performance can compromise patient care by limiting clinicians from going beyond their own skill set or scope of practice.[111]

Therefore, it is necessary to identify whether students or trainees have the capacity to accurately self-assess and if not, whether this skill can be taught in university or clinical settings.[57] The research also highlights the importance of identifying whether self-evaluation matches one's actual ability. Research literature suggests that self-assessment alone is not a sufficient predictor of clinical competence and recommends a comparative study between self and expert rating.[47,113,118] Thus comparison with expert assessment is important to establish the necessary skill level to achieve proficiency.[45,57,61] At present there are no published studies reporting on whether students are able to accurately self-assess their performance in orthosis fabrication compared to that of an expert. The tool developed in this study compared both self and expert ratings of performance.

2.5 Occupational therapy and hand splinting

The published literature in the field of hand therapy describes studies that report that the majority of hand therapists frequently provide hand orthoses as part of their treatment.[3,6,28] In addition, it has been reported that splint knowledge is critical to their practice, indicating that the design, selection, fitting, fabrication and training of orthotics continues to be an important aspect of hand therapy.[10,33] Research studies also identify the need for the development of evaluation tools to assess performance that can be used by both supervisee's and supervisors in the area of hand therapy.[10] In the literature reviewed, there was limited evidence of the development or testing of a competency tool for the psychomotor skill of hand orthosis fabrication.[98] Based on the gaps in the literature, the researcher in the current study created an assessment to measure the essential components of splint fabrication, including the necessary components of splint design – that of selection, fit and knowledge of the biomechanical principles. The assessment was designed for use with a variety of orthoses, within a clinical and university setting.

2.6 Summary

This chapter highlights the need for development of a validated and reliable assessment of splinting competence, which can be used in teaching environments for students and therapists at differing skill levels. The literature review focused on topics that underpin the main components of the research questions. The published literature described in this chapter highlighted the need for an assessment tool to reflect the expertise level from a supervisee and supervisor perspective and the importance of assessing a range of different orthosis fabrication steps and outcomes. The assessment should incorporate self and expert assessment of performance to identify whether students are capable of accurately assessing their performance in the skill of orthosis fabrication.

In the next chapter the author will describe the research design and objectives, providing detail of the current study's procedural steps, and a rationale for the chosen design.

3. Chapter Three: Methodology

3.1 Introduction

In the previous chapter, the author outlined the significance of the research project and highlighted the gap in literature in relation to assessing technical skill competence in the field of upper limb orthosis fabrication. This chapter provides a description of the research design and rationale for its use, the participant recruitment and inclusion process, and an explanation of the data collection methods and analysis.

3.2 Research Design

The research design was non-experimental, quantitative and correlational (Figure 3). The primary purpose of the research project was to develop a reliable and valid assessment, by identifying the degree of agreement between raters.[75] The study was designed and conducted in three stages in order to address the research questions outlined in Chapter One. In the first stage, a valid orthosis fabrication competency assessment was developed through gathering information from health science textbooks and journal articles and by consulting with experts in the field of upper limb rehabilitation. The second stage involved piloting the assessment with five expert hand therapists to measure the inter-rater reliability. The third stage of the study commenced once the assessment was determined to have achieved an acceptable level of reliability. In this stage, data was collected from student self-ratings and compared with expert scores of the same product, in order to determine whether the two scores were consistent and if not, whether the students were more likely to over- or under-estimate their performance.

3.3 Rationale for design

A quantitative methodology design was chosen as the most suitable method to measure reliability, thereby allowing the researcher to objectively analyse both ordinal and categorical data. In order to accurately determine the extent of consistency between the expert-expert and student-expert scores, the data needed to be collected and analysed empirically.[75] In the pilot stage, the content validity was established by gathering educational resources and by consulting with experts in the field. The consistency of the competence assessment was measured using inter-rater reliability data to compare five expert raters. Inter-rater reliability is widely documented in the educational literature as an important method for measuring the consistency of an assessment.[81]

Once the psychometric properties of validity and reliability were determined to be acceptable, the expert and student scores were collected and measured for consistency, in order to identify whether there was a correlation between expert and student measurement of performance. As discussed in Chapter Two, self-assessment alone was not seen as an accurate reflection of performance and in particular, those who showed poor performance were least likely to be accurate when self-rating.[87,118] The methodology included collecting student self-rated assessment scores, as well as an expert assessment of their skill performance, for comparison purposes. Figure 3 (page 61)represents a diagrammatic depiction of the research study design.

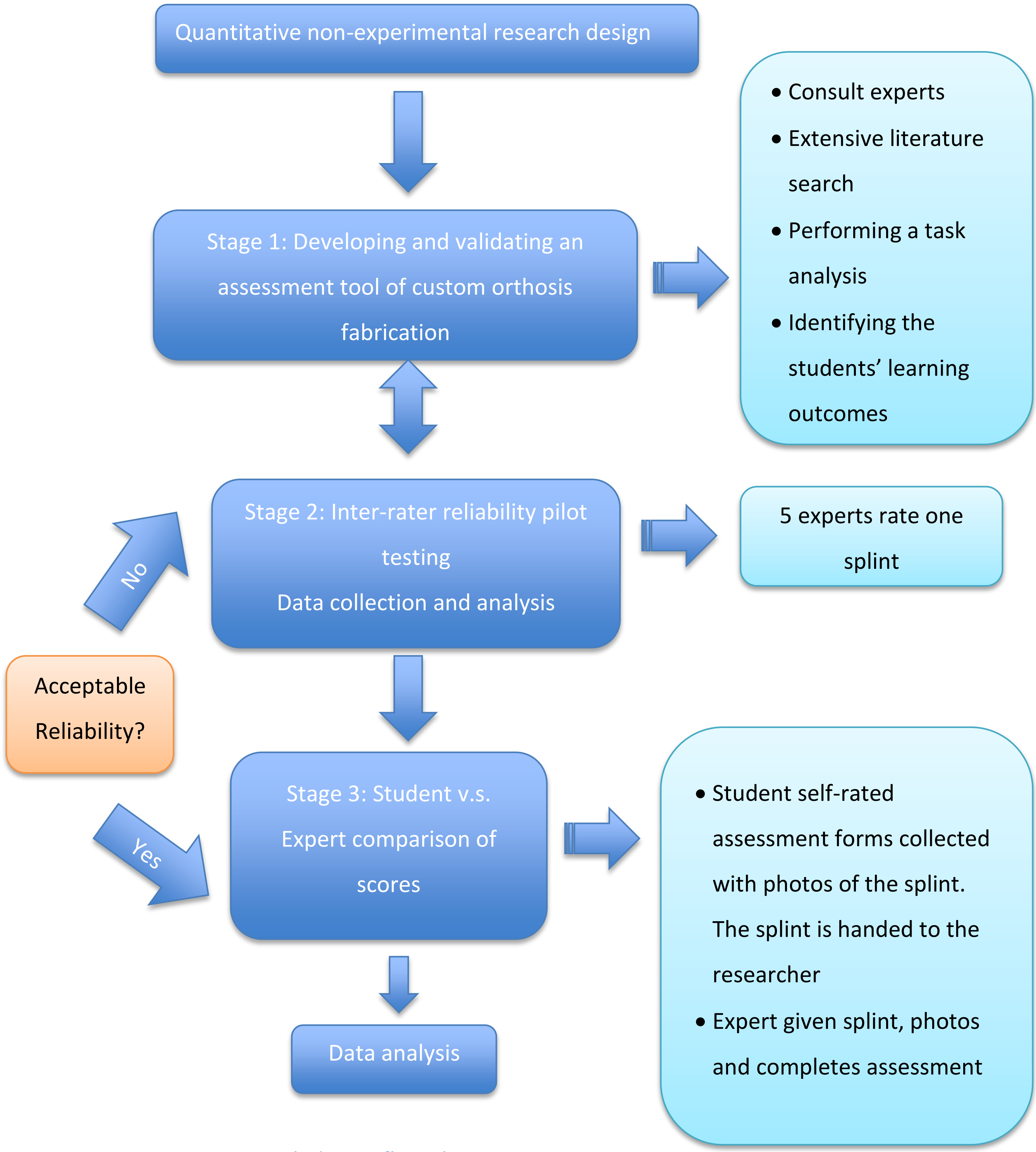

Figure 3: Research design flow chart

3.4 Population

The researcher was required to recruit a different population sample for each of the three stages of the research study. The research study included two cohorts each of participants, 'experts' and students.

For the first two stages of the research project a purposive sample of seven experts were recruited. An expert was defined as an occupational therapist with more than ten years' experience in the subspecialty of hand and upper limb rehabilitation. Initially, seven experts were consulted to provide feedback on a developed checklist and global rating scale, in order to establish content validity. Of the seven experts consulted, three were clinicians who also had previous experience in the teaching of hand and upper limb orthosis fabrication; one person was the owner of a hand therapy practice, employing junior and senior staff as well as supervising students regularly; two were senior hand therapists who worked at two different public teaching hospitals in Western Australia; and one was an occupational therapy university lecturer. Five of the seven experts were also included in the second stage of the research study, where the inter-rater reliability was tested. Two experts were excluded from the second stage because they lived in regional Western Australia and therefore it was logistically challenging to send and receive the pilot orthosis in time for the these experts to participate.

For the third stage, a purposive sample of undergraduate students were approached from two universities who offer Bachelor of Science Occupational Therapy courses in Western Australia. The students were recruited during an orthosis fabrication workshop from those enrolled in the Hand and Upper Limb Rehabilitation unit. In these sessions, the students gained practical experience through role-play and deliberate practice, fabricating custom thermoplastic hand orthoses. As part of the curricula for both universities, the students had completed lectures and/or tutorials based on the principles of design and fabrication of orthoses, prior to participating in the practical laboratory classes. The information in these sessions included identifying the design elements of an effective splint such as form, fit and function.

One university had 200 students complete the unit in first semester and the other had 40 in second semester. Therefore, the potential recruitment pool size was 240 students. Both cohorts were in the third year of their degree. Students were excluded from the research if they submitted incomplete assessment forms, failed to code their orthosis accurately, or if they did not submit the orthosis to their lecturer. The total sample size was made up of those that consented to be participants in the study, namely 108 students. Of this total sample, 82 splints were included in the study. Twenty-six students were excluded as they failed to complete their assessments, or to hand in their splint with the correct coding.

3.5 Procedures

3.5.1 Ethics approval and liaison with Universities

The research study was approved by The University of Western Australia Human Ethics Research Committee. Reciprocal ethics approval was granted from Curtin University of Technology and Edith Cowan University. The ethics approval number through The University of Western Australia was RA/4/1/7326 (Appendix 1). The Curtin University reciprocal ethics approval number was HR76/2016 and assigned a project number

6282 (Appendix 2). Edith Cowan University granted written permission to proceed with reciprocal ethics.

Participant information and consent forms were distributed to all potential participants in the second and third stage of the study. Signed participant consent forms needed to be collected for inclusion in the study. These were collected from the experts in the second research stage during inter-rater reliability testing and also from the students and experts involved in the third stage of data collection.

At the commencement of the third research stage, the unit coordinator for each site was contacted via email and a meeting was arranged to organise a time to present an introduction of the study to the students and discuss the logistics; such as collection of photographs and splints, and timeliness of taking photographs. This was essential to ensure that there were no disruptions to class time or any negative impact on the capacity of the students to complete their splints during laboratory sessions.

3.6 Data collection

3.6.1 Stage 1: Developing a valid orthosis fabrication assessment

3.6.1.1 Rationale for use of a rubric

The first step was to develop an assessment that was comprehensive in collecting data in an easy to administer format and which measured what it was designed to measure. It also needed to have the ability to discriminate between a novice and expert. An outcome-based, rather than a process-based assessment was favoured for this study design, as it was a retrospective assessment of student skill rather than in-vivo real time assessment of performance. Therefore, a rubric was chosen over a checklist.[57,97]

3.6.1.2 Development of the rubric

3.6.1.2.1 Content validity

To ensure the orthosis competency assessment measured what it was designed to measure, a variety of methods were employed.[122] Researchers suggest that content validity of an assessment is improved by gathering relevant information and through consulting experts in the field.[81]

In this study, the first competency assessment tool was designed as combination of a checklist and global rating scale. The researcher gathered information from medical and health science resources in order to design an assessment that included the correct content, demonstrated breadth of skill, measured what it was designed to measure and was in an easy format to administer.[59,96,98] The assessment tool segmented skills based on the biomechanical principles of orthosis design and fabrication documented in the literature (as outlined in Chapter Two). Additionally, the researcher adapted a previously validated tool from Stefanovich et al[64] who designed an assessment of splinting competence for use with a specific type of hand orthosis. Furthermore, experts in the field of hand therapy were consulted in the development of the assessment tool. Among the experts consulted was a university lecturer who was currently teaching the technical skill of custom thermoplastic splint fabrication to students in a practical laboratory setting. The researcher consulted the university lecturers and a rubric was provided to the researcher in order to identify the student learning outcomes for their practical laboratory sessions. The global rating scale was designed using this rubric in order to incorporate relevant learning outcomes and ensure the content of the assessment matched current university learning outcomes to further enhance content validity[75].

The initial global rating scale was developed using a five-point rating scale, with three descriptive phrases at ratings 1, 3 and 5.[123] The global rating scale was categorised into seven questions related to aesthetics, contours, fit, minimizing pressure, skin creases/dual obliquity, overall performance and quality of final product. Initially a checklist was included in the competency tool and designed as a 14-point assessment, divided into three criteria of form, fit and aesthetics. These three criteria have been identified in the literature to be important components of splint fabrication.[1,7,12,64] The checklist was scored using two ratings; whether a skill was or was not achieved. The assessment also included questions on participant demographics data of age, gender and first language spoken. The participants were also asked whether they had completed a fieldwork placement in the area of upper limb rehabilitation. The justification for the collection of this data was to identify whether there was a correlation between the students who had completed a placement in the sub-specialty of hand and upper limb rehabilitation and their ability to accurately rate their level of competence.

Once the initial assessment tool was drafted, experts in the field were further consulted to provide feedback and the tool was adjusted accordingly to ensure it had content validity.[40,122] The researcher designed a formal feedback questionnaire to seek information regarding the content, time to complete, layout and format of the competency assessment (Appendix 3). Following this, a description of the research study, a qualitative feedback questionnaire and the orthosis assessment tool were emailed to the experts. They were given two weeks to return their feedback to the researcher. Once collected, the feedback was compiled and used to amend the assessment in an effort to improve the face and content validity.

The researcher collated the written feedback and redesigned the assessment tool accordingly. Furthermore, based on the experts' feedback, and in order to improve the content validity of the orthosis assessment, the researcher included a reference key that provided an explanation for the medical terminology used in the rubric. The global rating scale and checklist were edited and the researcher was able to move onto the second stage of research (Appendix 4).

3.6.1.2.2 Construct validity

Construct validity refers to the extent to which a test measures the intended construct as well as the extent to which items of a test are derived from and are aligned to theory.[124] In the current research study, the construct validity was achieved by designing an orthosis competency rubric that included common themes derived from the published literature. The themes were grouped together under specific headings in order to measure different theoretical constructs, such as aesthetics, contour/fit and minimising pressure.

Discriminant validity falls under the umbrella of construct validity and refers to whether an assessment is able to discriminate different levels of skills and whether a test can distinguish between a novice and an expert.[122,123] The initial piloted global rating scale was designed as a 5-point rating scale with three descriptors at scores 1,3 and 5. After reliability testing, the researcher altered the global rating scale to become a three-point descriptive rubric. The researcher referred to the published literature and sought feedback from the experts, which provided sufficient justification to proceed with a 3-point descriptive rubric. Furthermore, the research literature suggests that descriptive rubrics are more effective at distinguishing between a novice and an expert, in comparison with checklists, when assessing technical skills.[47,121] It was identified that the use of a rubric to assess competency in orthosis fabrication provided satisfactory discrimination between a novice and expert clinician.

3.6.2 Stage 2: Reliability testing

3.6.2.1 Rationale for testing inter and intra-rater reliability

Inter and intra-rater reliability was the chosen method for testing the consistency of the competency assessment. Establishing a high level of inter-rater reliability is particularly relevant in a healthcare clinical setting where in many case the students and junior occupational therapy staff have multiple supervisors assessing a technical skill.[125] In the current study, the researcher measured inter-rater reliability by assessing the consistency of the rubric between five experts and between expert and student scores. In addition, intra-rater reliability is an important psychometric property of an assessment as it measures the reproducibility of an assessment over time, given the same assessor.[75] In the current study, the researcher administered the same orthosis competency assessment to three clinicians, with a one-month interval between the two tests, in order to test the intra-rater reliability of the assessment.

There are many methods to increase the reliability of an assessment; such as providing training to participants on how it is used, increasing the number and experience of the raters.[81,126,127] In this study, the researcher enhanced inter-rater reliability by explaining, to both the students and experts, how to complete the assessment form accurately. Furthermore, accuracy in scoring the assessment was increased by providing the experts with a breadth of information, such as multiple photographs and the physical splint. The experts were provided with all the information required to score the orthosis to complete the assessment in their own time, without the time restrictions of a university tutorial setting. The researcher did not act as an expert assessor in order to eliminate bias.

Another factor influencing inter-rater reliability is the clinical experience of raters.[127] The published literature suggests that increased experience of raters correlates positively with improved reliability of an assessment.[125,127] In this study, experts with more than ten years' experience in the field of hand and upper limb rehabilitation were purposively selected in order to increase consistency and reliability. Furthermore, other researchers suggested that by increasing the number of raters, the reliability of an instrument improves significantly.[127] In the current study, five expert raters were selected during the second stage of inter-rater reliability in an attempt to enhance the reliability of the instrument.

Research and education literature shows high reliability with the use of 5-point global rating scales and that the consistency of an assessment further increases with the use of objective descriptors in each category.[125,128] Research studies comparing four and six point scales showed that an increase in the number of categories does not always positively correlate with higher reliability.[95,125,127] On the other hand, other studies have indicated that reliability is independent of the number of options and that the objective descriptors in each rating alone may increase reliability.[95,128] After reliability and validity testing, the final assessment was designed as a 3-point descriptive rubric, with each descriptor explaining the various levels of ability.

3.6.2.2 *Testing inter-rater reliability*

In this stage, the inter-rater reliability was determined by comparing the scores of five experts with more than ten years' experience in the area of upper limb rehabilitation.[129] A sample splint was made by a junior occupational therapist and photographs were taken of the anterior, posterior and lateral sides of the splint when fitted to the researchers' hand. The researcher then contacted the five experts individually via telephone and email to arrange a time to visit them. Each person was provided with an introduction to the study, a participant information and consent form, and an assessment pack that included the sample splint, photographs of the orthosis fitted on the hand and the assessment forms to complete. The experts were asked to complete the checklist and global rating scale by looking at the photographs and orthosis provided in another room and allowed as much time as required. A sample of the photographs is shown below.

The researcher then analysed the data collected to determine the inter-rater reliability. The results from the data analysis showed that the initial global rating scale and the checklist had low reliability scores. Furthermore, after consultation with the experts, it was reported that the checklist did not accurately reflect the student's capability, in other words, the experts identified that they would 'pass' the splint, however the checklist score forced them to 'fail' the splint. Based on these discussions, the checklist was viewed as an inaccurate predictor of ability and did not have sufficient construct validity[64].The experts also felt the checklist did not allow for a variation in ability, such as discriminating between a novice and an expert or in being able to distinguish between an average and exceptional student. The majority of the experts also commented that they felt the global rating scale did not allow specific discrimination between skills. In other words, there were too many criteria in each question to maintain objectivity. It was suggested that more subcategories for each question be created and divided into more specific and measurable criteria.

Furthermore, after data analysis the question relating to “quality of final product” was found to show low reliability and created too much subjectivity amongst raters, thus the question was removed.

Based on the feedback from the experts and by analysing the reliability of each question, a revised orthosis fabrication global rating scale was created by using the content from the checklist and creating a larger 18 question assessment with 5 ratings and specific, objective descriptors at scores 1, 3 and 5 (Appendix 5). The revised rating scale was then piloted using the same five experts, with the same splint and photographs as shown in order to determine the inter-rater reliability. The same process outlined in Stage 2 was used (see Figure 3). The reliability was again assessed using the Fleiss kappa statistic and found to be more reliable, however it was insufficient to move on to stage 3. After further discussion with the experts and after analysing the reliability of each question in the scale for a second time, an orthosis rubric was developed. An extra question was added based on feedback from the experts regarding the positioning of the Velcro. Two questions were removed, as they were repeated in other parts of the assessment. The researcher also decided to change the scale from a 5-point global rating scale to a descriptive 3-point rubric, in order to reduce the variance of answers in each question. The researcher acknowledges that there is a limitation in changing the assessment from a 5-point scale to a 3-point scale as it potentially reduces the ability to show the spread of capability and proficiency of skill.[85,95,125] The researcher was aware that by reducing the breadth of scoring in the scale, that there was is a risk that it may not adequately distinguish between incompetent, novice, competent and expert. The revised rubric was re-tested in order to assess for inter-rater reliability, and again piloted with the same five experts, using the original orthosis and photographs. Thereafter, the experts were asked to provide feedback on the revised orthosis assessment, and specifically requested to comment on the change to a 3-point descriptive scale (Appendix 6). Upon receiving positive feedback from the experts, and after analysing the reliability data for the third time, a minimum acceptable kappa score was achieved. This allowed the researcher to move onto Stage 3 of the study.

3.6.2.3 Intra-rater reliability

The intra-rater reliability was tested with three occupational therapists, with more than one year's experience in the field of hand and upper limb rehabilitation. The three therapists were asked to complete the assessment, based on a splint and the photos of the splint fitted to the appropriate hand. The identical test was administered to the same therapists, with a one-month interval between the two tests.

3.6.3 Stage 3: Comparing the student and expert scores

The third stage of the methodology involved comparing the student's self-perception of performance with the expert assessor, in order to identify whether the students can accurately assess their competence. The researcher attended the two participating universities and presented the details of the research study to the students, during their hand and upper limb tutorial. Participant information and consent forms were distributed to the students, and the signed consent forms were collected at the end of the tutorial in a sealed envelope (Appendix 7 and 8). The researcher attended five different laboratory sessions and took photographs of the students splints fitted to the appropriate hand. The researcher also collected the students' completed self-assessments of splinting competence. Students were asked to label each splint and assessment form with a self-selected code in order to ensure anonymity. The students selected their own code and were encouraged to document and store it in order to ensure return of splints to the correct owner. The students were able to submit multiple orthoses of the thumb, hand and wrist for inclusion in the study. If the student had multiple orthoses, they would add a number at the end of their code corresponding to the number of splints submitted.

In the laboratory sessions, the researcher took photographs and the students were encouraged to complete the self-rated assessment forms at the end of each laboratory session in order to avoid impacting on university teaching time. The assessment forms were collected by the researcher and stored securely in a locked cabinet while the orthoses were submitted to the university lecturer for marking. Once marking was complete, the lecturer contacted the researcher who collected the orthoses that were marked with a label. The photographs were labeled with the same code and multiple views of the splint fitted to the hand were taken, including the lateral, anterior and posterior angles (Figure 4 and 5). Multiple views were taken in order to provide the experts with sufficient information to accurately complete the assessment forms. Anonymity was further ensured by the researcher, who took due care to ensure the photographs only captured the splint fitted to the hand and did not include the students' faces.

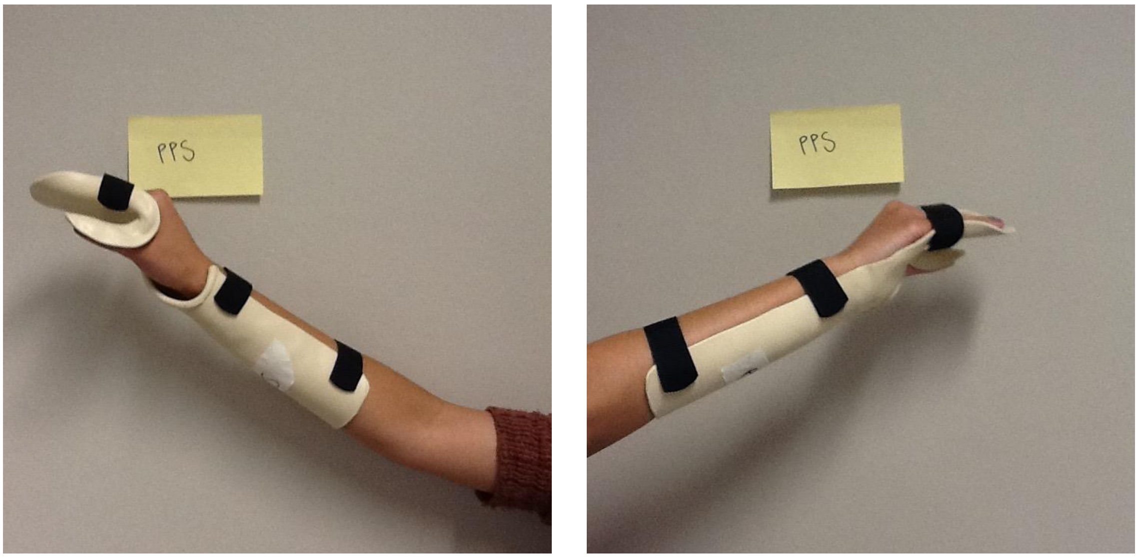

Figure 4: Lateral views of a resting splint

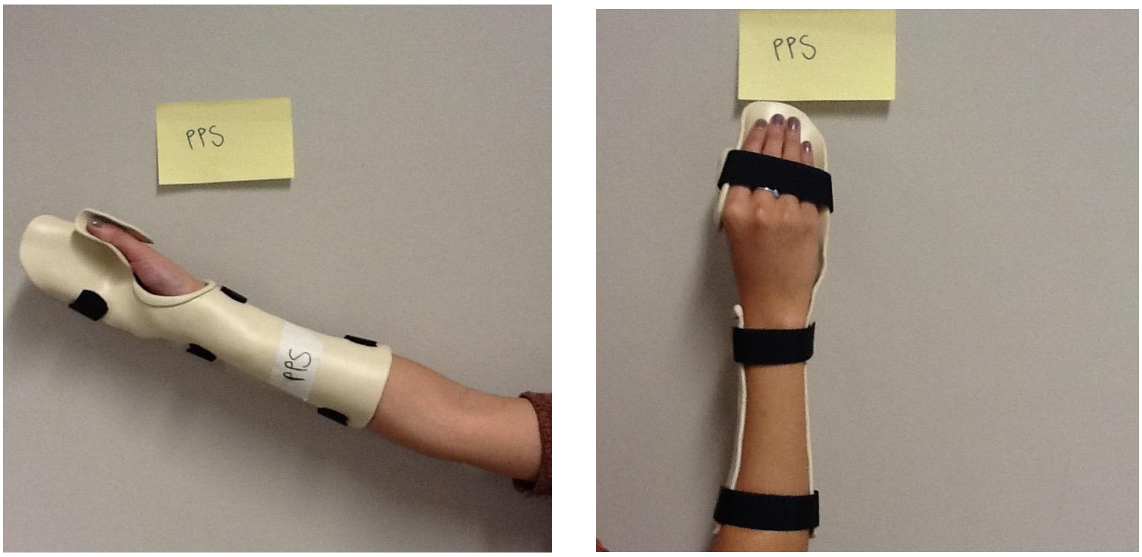

Figure 5: Anterior and posterior views of a resting splint

The students were able to submit as many splints as they wished. The splints were handed in to the respective lecturer for separate marking as part of the curriculum. Once the lecturer had completed their assessment of the splints, those that belonged to students who consented to participate in the study were handed to the researcher. After the data was collected, one expert hand therapist was provided with the orthoses and photographs and asked to complete the competency assessment in relation to these. The expert assessor was blinded with respect to the participants to eliminate bias[75]. The orthoses were returned to each student at the end of the research study.

3.7 Data analysis procedures

3.7.1 Data entry and storage

Data was stored both electronically on an external hard drive and physically, in a locked cabinet. The global rating scales that were returned were sorted and incomplete assessment forms were excluded from the data. During the second stage of research project, once data had been collected, the responses were manually entered into an Excel spreadsheet and the Fleiss' Kappa formula was applied, for statistical analysis. During the third stage, the raw student and corresponding expert scores were first entered into an Excel spreadsheet and then imported into IBM SPSS Statistics Version 25 for statistical analysis.

3.7.2 Reliability and validity of global rating scale

In order to answer the second research question, relating to the reliability of the competency assessment, a variety of methods were used to measure the consistency between the expert scores and between the different periods of time. The inter-rater reliability was examined in the first stage using the Fleiss' kappa statistic in order to determine the consistency between multiple expert raters[81,130]. The kappa statistic is viewed as a sophisticated inter-rater reliability measure as is accounts for agreement between raters occurring by chance[81,130]. The inter-rater reliability was computed using the Fleiss' kappa statistic on Microsoft Excel and a k value was calculated for the checklist and global rating scale. A minimum inter-rater reliability score of 0.6 was required to continue to stage three.[57,68,75,95,115,125] Based on the guidelines from research studies a kappa (κ) score of 0.6 represents a moderate strength of agreement.[131]

The internal consistency of the assessment tool was analysed using Cronbach's alpha.[132-134] In addition, the correlation between the first and second tests was determined using the Pearson's correlation coefficient.[75,135] A Pearson's correlation of 0.6 or above and a Cronbach's alpha of 0.7 or above were considered acceptable in order to describe the assessment as having intra-rater reliability and internal consistency, respectively.[135]

3.7.3 Analysis of the student and expert scores

In order to investigate if there was a statistically significant difference between the student and the expert scores, a paired samples t-test was used. The overall expert and student scores for the orthosis competency assessment were analysed in IBM SPSS Version 25. A paired samples t-test was the preferred method of analysing the difference between the student and expert scores and identifying whether the difference was statistically significant.[75,136] Furthermore, a test of Pearson's correlation was performed to identify the correlation between student and expert scores[75]. The Pearson's correlation is a common method of reporting the consistency between expert and self-rated scores within medical and surgical published studies.[117,121] *r* are .1, .3, and .5.

Firstly, the data was assessed to identify whether it was a parametric or normative distribution. This is a prerequisite for using both the paired samples t-test and the test of Pearson's correlation.[57,137] A p value of 0.05 or less was considered statistically significant.[138] Furthermore, the effect size was analysed to identify the magnitude of the statistical significance of the scores. Statisticians report that larger sample sizes have a higher chance of computing a higher statistical significance and therefore it's important to analyse the magnitude of this significance.[138,139] The Cohen's d statistic was used to calculate the effect size of the significance.[138-140] Cohen reported the value of the effect sizes to be interpreted as: d=0.1 for small, d=0.3 for medium and d=0.5 for large effect sizes. [140]

3.7.4 Establishing a minimum standard of competence for orthosis fabrication

Three experts were approached from the second stage of the research study, to advise on the minimum standard of competence required for orthosis fabrication, using the rubric developed for this study. The experts were requested to score the importance of each skill subset in the assessment by identifying a minimum score required to 'pass' each criterion. The results of the experts' skill rankings were combined and averaged to form an overall minimum score, in order to identify the baseline score required to achieve competence in the skill of hand orthosis fabrication.

3.7.5 Providing opportunities for student learning

At the end of the research process, after the data analysis was completed, the researcher returned the expert and self-assessment forms to the respective students.

This provided an explicit learning opportunity to the students by allowing them to compare their self-assessment to that of an expert. The goal of providing feedback in the learning cycle, assists students to develop the tools for future self-improvement and development.[92]

3.7.6 Summary

This chapter provided a description of the methods used to answer the research questions and specified a rationale for the chosen methods employed. Secondly, a detailed description of the data collection methods and justification of their use were included. Finally, the data analysis procedures were outlined. The following chapter presents the findings of the study.

4. Chapter Four: Findings

4.1 Introduction

In the previous chapter, the author discussed the research process including a description of the design, sample population and data analysis procedures. In this chapter, the results from the inter-rater reliability testing as well as the comparison of expert and student scores are presented. This chapter will also include the demographic data of the expert and student recruitment population.

4.2 Recruitment

In the first stage of the research study, a purposive sample of seven experts was approached to provide feedback for validity purposes, and of those, five agreed to be included in the study. In the second stage of the study, five experts were approached to be included in the inter-rater reliability testing and all of these agreed to participate. The third stage involved recruiting university students, who were in the process of studying occupational therapy and were enrolled in the laboratory session for splint fabrication. Of the 240 students who met this criteria, 62 students were included, 18 of which handed in more than one splint. This resulted in a total sample size of 82 splints assessed and included in the data analysis for this study.

4.3 Demographic data

4.3.1 Gender

Of the 62 students included in the research study, 93.8% were female. This finding is consistent with the data reporting on the percentages of male and female occupational therapists in the workforce. The Australian Health Practitioner Regulation Agency released an annual report for 2016/2017 that stated the figures for registered occupational therapists in Western Australia were 91.75% female, 8.25% male and nationally 91.3% were female.[141]

4.3.2 Age

Students between the ages of 19 to 23 represented the majority (n=45; 80.3%) of the participants. The included participants ranged between 18 to 34 years old.

4.3.3 Fieldwork experience

A majority of the students (n = 52; 83%) had no prior hand therapy practical fieldwork experience.

4.3.4 Analysis of content validity

In the first stage of the research project formal feedback, through the use of a qualitative questionnaire, was gathered from five experts who provided advice on the content validity of the competency assessment. The length of time for completion ranged from two to ten minutes, with one therapist reporting it took 60 minutes to complete. In terms of concurrent validity, one expert compared the new orthosis assessment form with a marking grid from a West Australian university, and reported they achieved similar results (the university test resulted in an 81% score while the current study's tool resulted in an 83% score). Furthermore, the experts provided suggestions regarding the appropriateness of the checklist "I don't understand why there are two forms?" and another expert said "yes or no is not pertinent to teaching, and seems to not acknowledge learning or degrees of improvement”. A majority of the experts recommended combining the two assessments into one summative assessment. In relation to the content and structure of the assessment, the experts made recommendations regarding the consistency and correct use of hand therapy terminology, with one suggesting “consider ‘orthosis fabrication checklist’ rather than orthotic, as this is not the correct hand therapy terminology used at the moment”.

Further suggestions included comments in relation to the layout of the assessment. As one expert wrote, “Consider removing the lines that extend beyond the box” and another said that the “demographic data is a bit jumbled”. Based on the feedback, the researcher altered the assessment tool by changing the title of the tool to being named an ‘orthosis fabrication competency assessment’. Furthermore, based on the feedback from the experts, the researcher adjusted the format of the assessment tool to capture demographic data at the beginning of the form.

4.3.5 Analysis of construct validity

A factor analysis was conducted to determine whether there were links between common factors or constructs. Five constructs were identified through the factor analysis. Table 1 (see below) presents the questions that have a high level of correlation ($r>0.6$) between a question and a construct (highlighted in yellow), and those questions that had a low correlation with all the constructs ($r<0.3$). It should be noted that one question was removed because it did not correlate with any of the factors. Questions relating to the heading of ‘contour and fit’ of the orthosis showed moderate to high consistency and correlation. Similarly, the questions grouped under the heading of measuring competency in 'aesthetics' showed moderate to high correlation. Three questions had a low to moderate correlation with all the factors.

Table 3: Factor analysis of the orthosis competency assessment.

Rotated Component Matrix

	Heading/theme of the question	1	2	3	4	5
q1	Aesthetics	-.218	.004	.089	.722	-.098
q2	Aesthetics	.350	.561	.296	-.202	-.133
q3	Aesthetics	-.113	.068	.680	.021	.322
q4	Aesthetics	-.075	.090	.703	-.111	-.023
q5	Velcro and strapping	-.015	.681	-.124	-.004	.249
q7	Velcro and strapping	.026	.066	-.026	.778	.042
q8	Velcro and strapping	.426	-.025	-.572	-.193	.164
q9	Contour and fit	.651	-.206	.162	-.002	.093
q10	Contour and fit	.739	.229	-.170	.014	-.147
q11	Contour and fit	.649	.166	-.238	-.138	.083
q12	Contour and fit	-.162	.383	-.234	.002	.621
q13	Contour and fit	-.146	.798	.262	.066	-.041
q14	Minimising pressure	-.216	.154	.102	-.397	-.161
q15	Minimising pressure	.641	-.022	-.048	.001	-.139
q16	Skin creases/dual obliquity	.032	-.049	.257	.055	.777
q17	Skin creases/dual obliquity	.670	-.194	-.214	.083	.017

4.3.6 Analysis of internal consistency

Cronbach's alpha was used to measure the internal consistency of the orthosis competency assessment tool.[132] An acceptable Cronbach's alpha would be 0.7 or above.[68,132] The orthosis assessment showed a low internal consistency between the individual items within the scale (a=0.4). Question 1 showed the lowest correlation when compared with the other questions. When question 1 was deleted, the Cronbach's alpha was still not at an acceptable level to show adequate internal consistency of the assessment (a=0.5).

4.3.7 Analysis of inter-rater reliability

Inter-rater reliability was assessed using Fleiss' kappa statistic.[85,142,143] Fleiss' kappa statistic (k) was used as it measures the consistency of scores between more than two raters, and takes into account the likelihood of the scores occurring by chance.[143,144] The Fleiss statistic is calculated by working out P(bar), the mean of all the proportions of the raters who agree, and Pe, the mean of the proportions of raters agreeing solely due to chance.[143] Using the Fleiss' kappa table of reliability as a benchmark (Table 4), a reliability score of 0.6 or above was considered an acceptable level of agreement between raters, in order to move onto the final stage of the research study.[144] Furthermore, in the health science literature, a kappa score of 0.6 and above is viewed as acceptable reliability between raters.[125,144]

Table 4: Fleiss' kappa benchmark[144].

Kappa Statistic	Strength of agreement
<0.40	Poor
0.40-0.75	Intermediate to Good
>0.75	Excellent

4.3.7.1 First pilot

The level of consistency between five expert raters for the global rating scale computed a very low reliability score (Pbar=0.25, Pe=0.29, k=-0.06) and similarly, the checklist showed a low reliability score (Pbar=0.7, Pe=0.5, k=0.38). As a result of the low Fleiss' kappa score, the researcher reverted back to the first stage of the research study in order to adapt test items to improve consistency in the scores assigned by the raters. The results of both the checklist and the global rating scale, which was computed in Excel using the Fleiss' kappa formula.

4.3.7.2 Second pilot

After altering the first splint fabrication assessment to a revised global rating scale and removing the checklist for reasons of poor validity, the same inter-rater testing process was repeated with the same five experts. Again, the reliability score for the altered global rating scale was analysed using the Fleiss' kappa statistic and the results showed that the revised assessment had low to moderate reliability (Pbar=0.58, Pe=0.27, k=0.43). Although the revised orthosis assessment tool was found to be more reliable than previously found, it was still considered too low in order to move on to the third stage of the study.

4.3.7.3 Third pilot

The process was repeated as per stage two of the research design and the final rubric measured moderate and acceptable inter-rater reliability (Pbar=0.79, Pe=0.47, k=0.6). This enabled the researcher to move onto the third stage of the research design, that of comparing the student and expert scores for the same splint.

4.3.8 Intra-rater reliability

Test-retest reliability was measured using Pearson's correlation[117,121,137]. The results show a moderate correlation (r=0.6, Table 5) between the first and second test timeframes.

Table 5: Pearson's correlation for intra-rater reliability

	Test 1	**Test 2**
Test 1		
Pearson Correlation	0.623	1
Sig. (2-tailed)	0.000	
n	51	51
Test 2		
Pearson Correlation	1	0.623
Sig. (2-tailed)		0.000
n	51	51

4.3.9 Analysis of student versus expert scores

The overall means of the student scores were compared against the means of the expert scores. Prior to analysing the paired samples, it was necessary to determine whether the data was normally distributed.[57,75] The data were imported into SPSS and was shown to be normal in distribution (Figure 6).

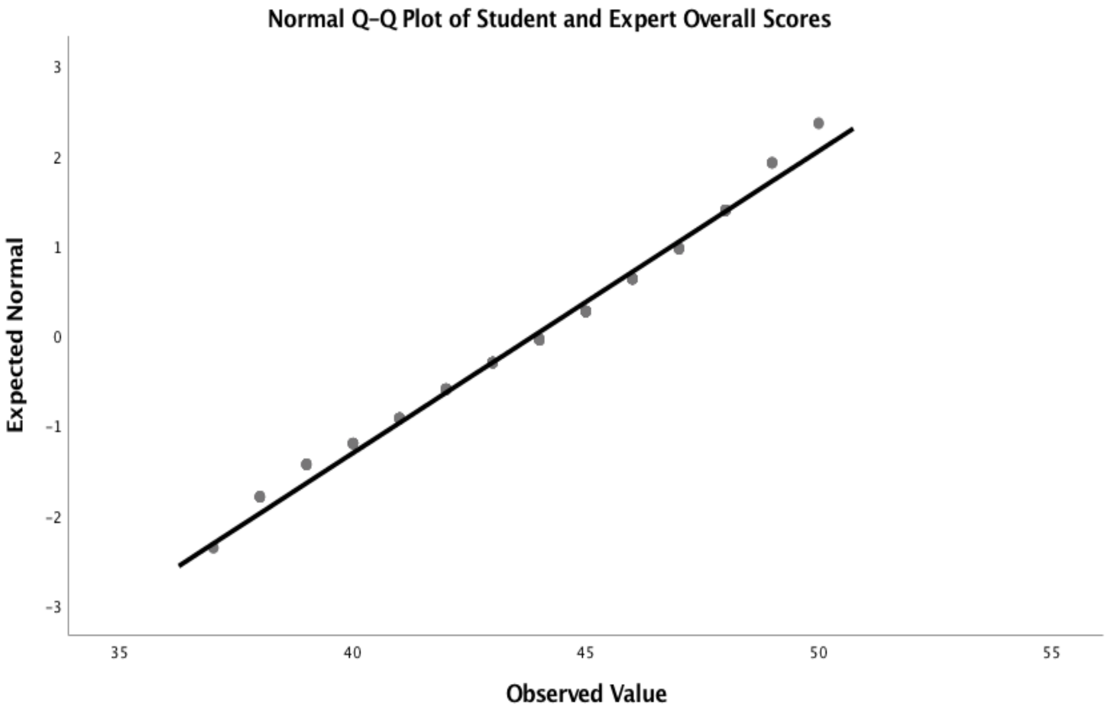

Figure 6: Q-Q plot showing the normal distribution of the data.

4.3.9.1 Paired Samples Statistics

Once the data was determined to be normal in distribution, the researcher analysed the difference between the overall mean scores for the students and the experts using a paired samples t-test.[57,137] The paired samples t-test was used to identify if the difference in the scores was statistically significant.[57,137] A paired samples t-test showed that there was a difference between the student and expert scores and that this difference was found to be statistically significant (p=0.00, Table 6).

Table 6: Paired samples t-test showing the statistically significant difference between the mean scores.

Paired Samples t test	Overall mean	***Paired differences*** Mean	Std. Deviation	Significance (2-tailed)
Student overall score	44.93			
Expert overall score	42.85			
Pair: Student – Expert overall paired score		2.073	3.530	.000

4.3.9.2 Effect size

Once it was found that there was a statistically significant difference between the scores of the students and experts, it was necessary to measure the magnitude of this difference by using the Cohen's d calculation.[138-140] The formula to calculate Cohen's d is the mean divided by the standard deviation of the paired samples t-test.[138,145] An assessment of the effect size using Cohen's d showed a moderate (d = 0.6) level of magnitude of difference between the means.[138,140,145] Therefore, it was found that the magnitude of the difference was considered acceptable to demonstrate that there was a significant difference between the mean scores of the students and experts.

4.3.9.3 Correlation between the student and expert scores

The Pearson's correlation was used to identify the consistency between student and expert scores.[117,121] The table below shows a low correlation between the scores for the students and experts (r=0.2, Table 7).

Table 7: Pearson's correlation between the expert and student scores

	Student overall score	Expert overall score
Student overall score		
Pearson Correlation	1	0.20
Sig. (2-tailed)		0.06
N	82	83
Expert overall score		
Pearson Correlation	0.20	1
Sig. (2-tailed)	0.06	
N	83	82

4.3.9.4 Under or overrating performance – comparing the student and expert means

The overall mean scores of the rubric for assessing competence in orthosis fabrication showed that the students were more likely to over-estimate their overall scores, compared to the expert (students' mean=44.93; experts' mean=42.85).

4.3.10 Differences between scores based on splint type

The data showed that the mean difference between the student and expert scores increased when the students assessed their thumb splints compared to the resting splints as shown in Figure 7.

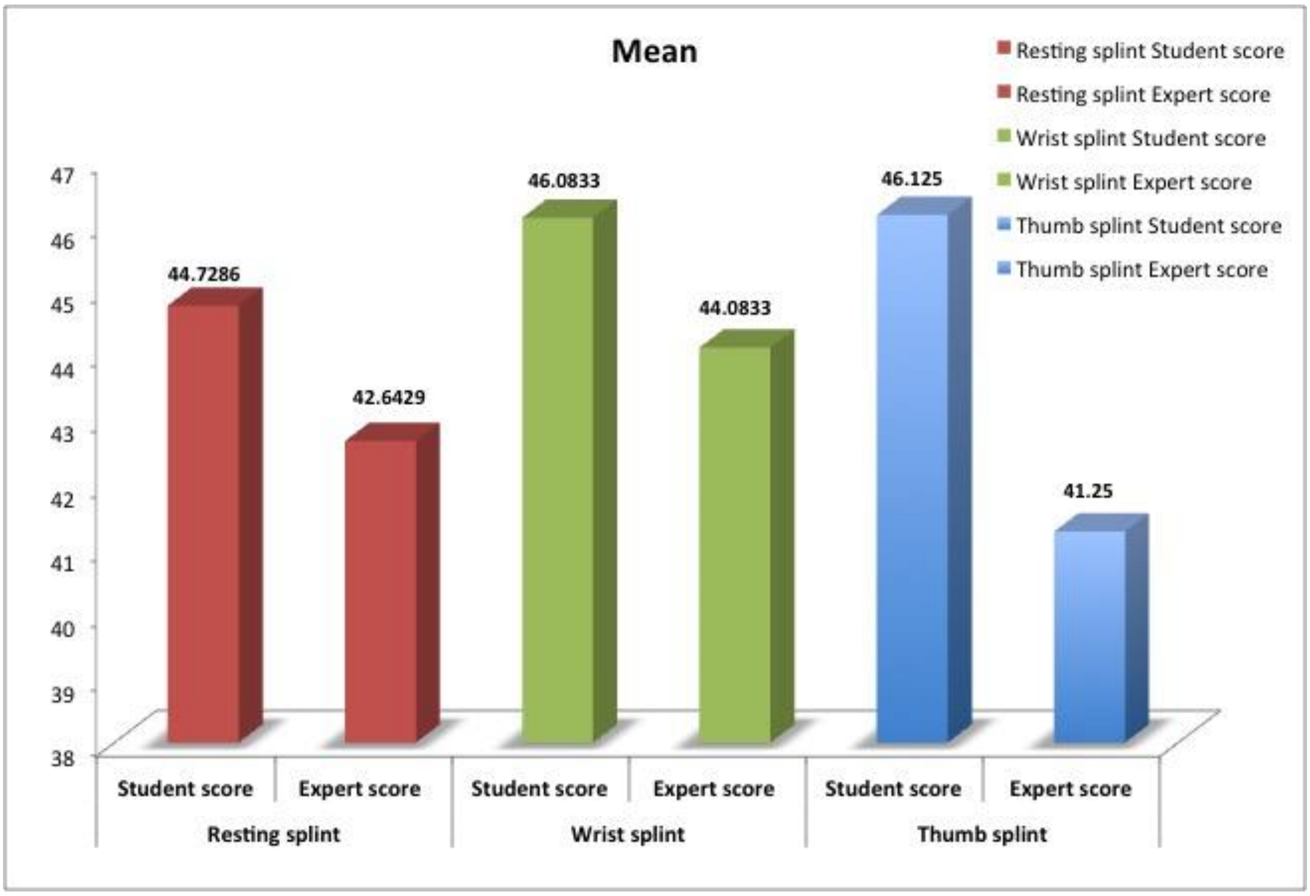

Figure 7: The mean difference between the student and expert scores based on splint type.

4.3.11 Mean difference in scores based on quartile rank

The results show that there was a significant difference in the mean scores between the students' self-perceived score and their actual score i.e. the expert score, based on the quartile rank. The students who scored in the lower percentile (25^{th} percentile) were less accurate at scoring their performance compared to an expert (mean difference=4.28, Table 8). This difference was statistically significant (p=0.00, Table 13). However, there was no significant difference (p=0.3; mean difference=0.7) in the mean scores between the expert and the students who were ranked in the highest quartile (75^{th} percentile, Table 9).

Table 8: Comparison between the expert and student mean scores for students in the 25th percentile range.

Paired Samples Statistics

				Paired Differences		
Bottom quartile (25th percentile)	N	Mean	Std. Deviation	Mean	Std. Deviation	Significance (2-tailed)
Pair: *Expert scores*	25	39.80	1.32			
Student scores	25	44.08	3.79			
Pair: Expert-Student scores				-4.28	3.69	.000

Table 9: Comparison between the expert and student mean scores for students who performed in the 75th percentile range

				Paired Differences		
75th percentile	N	Mean	Std. Deviation	Mean	Std. Deviation	Significance (2-tailed)
Pair: *Expert scores*	20	44.60	0.50			
Student scores	20	45.30	2.96			
Pair: Expert-Student scores				-0.70	2.79	0.28

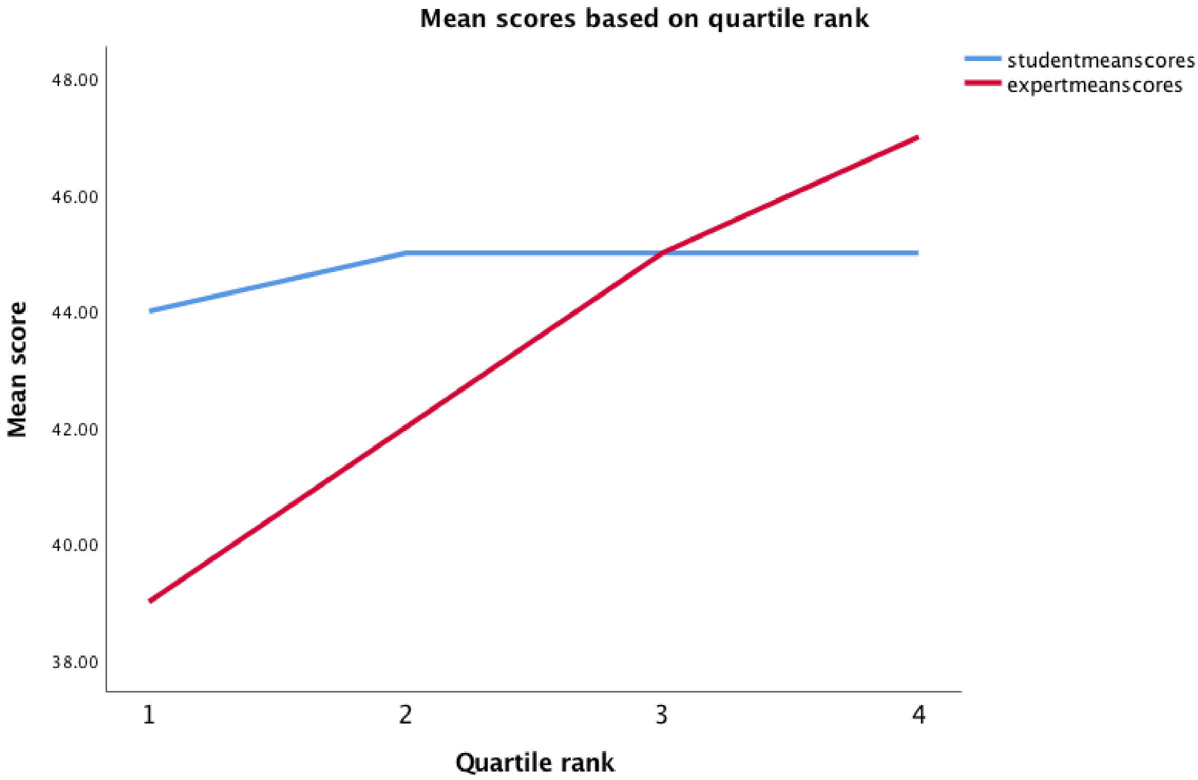

Figure 8: A line graph showing the difference between the mean expert and student scores based on quartile rank.

In summary, the mean difference between the expert and student scores of those who performed in the bottom quartile was significantly larger than those who performed in the top 75%, with the tendency for these students to significantly overestimate their performance compared to the expert. In contrast, the students who performed in the top quartile showed they were more likely to be accurate in rating their performance, with a tendency to underestimate their performance compared to the expert rating (Figure 8).

4.3.12 Minimum level of competence achieved

The researcher consulted with two experts to reach consensus that the minimum score of 34 out of a possible 51 (a score of 67% or more) was required to achieve competence in orthosis fabrication for the particular splint being assessed.[47] All of the students scored 38 or above and therefore all reached the minimum score to achieve competence in orthosis fabrication.

4.4 Summary

In this chapter, the findings from the research study have been presented. The demographic data for the student cohort was outlined and the inter- and intra-rater reliability of the orthosis assessment tool, were presented. Additionally, the results of the feedback questionnaire given to the experts to improve content and face validity were summarised. Furthermore, the results of the comparison and the correlation between the expert and student scores were included. Specifically, the data was analysed by dividing the students into performance categories to identify whether the students who were in the lower performance category were able to accurately identify their level of performance, compared to the expert score. The next chapter will discuss the findings with reference to answering the research questions presented in Chapter one.

5. Chapter Five: Discussion

5.1 Overview

Occupational therapists are required to be competent in a variety of performance domains. The drive to provide evidence for competence has been guided by the new minimum standards for occupational therapists, within the framework of the allied health registration requirements.[141] Similarly, universities in Australia are required to provide evidence that their students are meeting the competency standards developed by the Occupational Therapy Council through a process of accreditation.[13] Furthermore, occupational therapists have a duty of care to provide the best outcomes for their patients, built on the principles of evidence-based practice, by maintaining their professional standards. In addition, it is necessary to assess competence using a standardised method of measurement which is both valid and reliable.

The literature review chapter highlighted the gap in the published studies, relating to the availability of a generic assessment of performance in orthosis fabrication. The research suggests that the skill of self-reflection can enhance lifelong learning. However, the published studies are inconclusive as to whether students can accurately self-rate their performance compared to an expert. Based on this, the researcher of the current study designed an orthosis fabrication assessment tool to measure competence in generic splinting skills. The study also included a comparison between students' self-assessment and the expert scores, in order to identify whether the students were able to accurately rate their performance. Inaccuracy in self-assessment of performance has implications for structuring teaching methods and designing the university curriculum. If students are unable to accurately rate their performance, does this imply they lack understanding of the principles of design and fabrication? Does the curriculum need to focus on the development of self-critique skills and improve on the students' understanding of the learning outcomes? These questions will be explored in this chapter.

In this chapter, the four research questions proposed in the first chapter will be discussed, with reference to the findings that were shown in chapter 4 and compared with the information available from the published literature. This chapter will conclude with a discussion of the limitations of this study and will provide suggestions for future research.

The research questions that will be addressed in the following paragraphs are as follows:

1. Does the newly developed hand orthosis tool have content, face and construct validity?
2. What is the inter-rater reliability of the hand orthosis assessment tool?
3. How do students assess their performance in the technical skill of orthosis fabrication compared to an expert?
4. If there is a difference between student and expert assessments, are students more likely to over or under estimate performance using the hand orthosis assessment?

5.2 Validity of the orthosis assessment tool

In answering the research question on the validity of the hand orthosis assessment it is necessary to determine the psychometric properties of the tool to identify whether it is suitable to be used for its intended purpose.[75] An assessment must measure what it is designed to measure in order for it to be valid.[75] Validity can be subdivided into several types. The current study focused on content and construct validity.

5.2.1 Content validity

Content validity relates to the ability of an assessment to capture the subset of skills required to perform a task.[75] The measurement of the content validity of an assessment is subjective, as it is difficult to measure statistically.[76,78] Both quantitative and qualitative methods have been reported as being used to analyse the psychometric properties in order to determine the content validity of an assessment tool. Quantitative methods such as the use of the content validity index are resource-intensive. Qualitative methods use descriptive methodology such as consulting with 'experts' and linking the assessment to learning outcomes.[75,122] This study used a combination of qualitative methods to improve the content validity of the developed assessment of splinting skills. The content validity of the assessment tool was improved by consulting with 'experts' in the field of hand and upper limb rehabilitation, as well as by adapting an existing assessment by Stefanovich et al[64] that had been previously validated.[76]

In this study, the researcher adapted an assessment tool that showed validity and reliability from a previously published study by Stefanovich et al.[64] This was used it to provide the structure and content for the newly developed orthosis fabrication competency rubric. In addition to this, the researcher used textbooks and accessed the published literature relating to the field of hand therapy. The researcher used the background information gained from these resources to perform a task analysis of the skill of orthosis fabrication, which enabled deconstruction of the motor skills into measurable components.[75] The researcher then used this information to design the 'new' assessment into measureable subheadings -such as aesthetics, fit and minimising pressure.

Furthermore, the researcher consulted with 'experts' in the field of hand therapy, using a formal questionnaire to seek feedback regarding the feasibility, usability and content of the assessment. The experts provided feedback regarding the content, structure, format and application of the assessment, and the rubric was adjusted accordingly.

Finally, the researcher cross-referenced the skill outcomes of the developed rubric with the learning outcomes in the students' hand therapy unit. Therefore, the combination of consulting with 'experts', adapting a previous assessment, referencing theoretical constructs and matching the content to the learning objectives, combined to improve the content validity of the orthosis fabrication global rating scale.[75] It can be postulated that the orthosis competency assessment had appropriate content and face validity, based on the methodology used to develop the assessment.

The process of improving content validity did not occur in isolation; rather it was applied throughout the three stages of the research methodology. The assessment was adapted from a checklist and global rating scale to become a descriptive rubric, describing the varying levels of performance. The changes were based on continuous feedback received from the 'experts' as well as through further analysis of the necessity of inclusion of each item in the tool. This cyclic, evaluative process enabled the researcher to adapt the assessment to improve the content validity.[75]

5.2.2 Construct validity

Construct validity refers to the ability of an assessment to measure the construct it is intended to measure, and is determined by analysing the internal validity.[75,146] Internal validity refers to how the items in a test relate to a theoretical construct, and is measured using factor analysis.[75,146] In this study, the factor analysis results identified five theoretical constructs within the competency rubric. The analysis showed that some questions had moderate to high consistency, and that they all related to the construct of 'contour and fit' of the orthosis. Similarly, other questions showed moderate to high correlation and were grouped under the heading of measuring competency in 'aesthetics'. However, the remaining questions that showed a moderate to high level of consistency within a construct, did not relate to each other when examined using the principles of orthosis design.

An explanation for the variation in internal consistency between the test items can be attributed to the structure and design of the rubric. The scale was designed so that each item was marked using three descriptive criteria, in order to increase the inter-rater reliability of the assessment. The published literature reports the use of a five-point Likert scale that captures variation in performance, when used to assess the technical performance of students.[67,85] In the current study, the use of a three-point descriptive rubric potentially reduced the variation between the test item scores, and thus statistically the factor analysis could not compute the different constructs.

The published education literature documents the potential threats to the construct validity of an assessment, such as assessor bias and student characteristics.[147] In relation to the current study, the assessor may have rated two psychomotor skills differently within the one performance domain and therefore the consistency between constructs may be altered. For instance, in relation to the 'minimising pressure' sub-heading of the orthosis assessment, a student may have performed well in achieving the correct surface area of the splint, however may not have flared or rolled the edges to prevent friction with the skin. Therefore, statistically these performance domains did not show consistency within a theoretical construct.

5.3 Reliability of the orthosis competency scale

To answer the research question of measuring the reliability of the orthosis assessment tool, inter- and intra-rater reliability were measured. In this study, multiple forms of reliability testing were used to identify the consistency of the orthosis assessment; including inter-rater, intra-rater and measures of internal consistency.

5.3.1 Inter-rater reliability

"The largest threat to reproducibility of clinical evaluations is inter-rater reliability". [53p.49] It is necessary for the assessment of a skill to be consistent between two or more raters, in order to ensure the tool can be reproduced and minimise the errors that may occur in rating performance.[95] Establishing a high level of inter-rater reliability is particularly relevant in a healthcare clinical setting, where often the students and junior occupational therapy staff have multiple supervisors assessing a technical skill. Inter-rater reliability is improved in many ways, either by providing training on the use of the assessment, or by selecting experienced raters.[95,148]

This study measured the inter-rater reliability of the orthosis fabrication assessment, using the Fleiss' kappa statistical measurement.[125] Initially, acceptable inter-rater reliability was difficult to establish. The assessment required three pilot tests in order to improve the consistency between the expert raters. The first pilot test showed poor consistency of scores between the five expert raters. As a result of the poor inter-rater reliability scores and after further discussion with the experts, the researcher decided to remove the checklist and adjust the global rating scale. The items considered important in the assessment of an orthosis were adapted from the checklist, and added to the global rating scale, in an attempt to improve the consistency between raters.

The researcher again piloted the adapted assessment tool with the experts, and the inter-rater reliability improved, however this was still considered insufficient to progress to the final stage of the research study. Finally, the inter-rater reliability improved to achieve a minimum acceptable standard, as the tool was again adapted to measure more specific skill subsets and include descriptive criteria in the marking grid, using a rubric format. The researcher altered the assessment from being a five-point scale to then including three descriptive criteria for each skill subset. After the third pilot, the newly devised rubric achieved the minimum acceptable reliability for a low stakes performance task. The researcher chose to move onto the final stage of the study when the minimum acceptable level of reliability was achieved.[148]

In this study, the difficulty in achieving an acceptable level of reliability of the orthosis competency rubric may be attributed to the varied experience, clinical training and expectations of the experts.[81,131] For example, in clinical practice, therapists have varying techniques for splint fabrication -for instance, some clinicians choose to flare the edges of their splint, while others prefer to roll in order to prevent friction.[1,8] Therefore, the moderate inter-rater reliability score that was calculated may be attributed to the variation in standards of splint design and fabrication between clinicians.[1,8,122]

5.3.2 Intra-rater reliability

It is necessary for an assessment to be consistent and reproducible, both between raters and with the same rater at different periods of time.[75,78] The intra-rater reliability of the orthosis competency assessment tool was shown to be acceptable, in relation to the measurement of internal consistency and correlation between expert and student scores. In this study, there was a high level of consistency for each rater, between the different points in time. The finding of high internal consistency indicates that the orthosis competency assessment is accurate in its reproducibility over time. The low level of correlation and moderate to high level of internal consistency described in this study are consistent with the findings in the published literature in the fields of medicine and education.[133,149] The published literature documents variability in the intra-rater consistency with the use of rubrics, with some studies suggesting the variation is due to the experience of the rater and the type of rubric used.[149]

There are various possibilities that explain the high internal consistency between raters found in this study. The first explanation is that a well-designed rubric directly impacts on the high levels of consistency in assessment. Firstly, the rubric was designed with clear and consistent criteria to measure levels of performance in splint fabrication. Furthermore, to reduce the variability in ratings between periods of time, the medical terminology used in the assessment was clearly defined by providing a key as reference point. Secondly, the rubric was designed to measure the specific skills in orthosis fabrication and the research suggests that the more specific the criteria in a rubric is, the higher chance of internal consistency and reliability.[134]

5.3.3 Internal consistency reliability

The measure of internal consistency of an assessment refers to how well the individual items of the test correlate with the overall test score.[68,132] In this study, the analysis showed a low internal consistency of the assessment. One possible explanation of this is that the assessment was designed to reflect the specific skills of orthosis construction, and no attempt was made to develop a scale that would unify all the items within the assessment. Each item in the test represented specific subset of skills within each performance domain, and was agreed upon by experts in the field of hand and upper limb rehabilitation. Furthermore, the low internal consistency can be attributed to the small number of test items as well as the limited number of choices within each item of the assessment tool. The internal consistency of an assessment increases with the number of items in the assessment as well as the amount of choices within each item.[132]

5.4 Student assessment compared to an expert

The third research question was addressed by analysing the difference between the student and expert scores in order to determine whether the students can accurately self-assess their performance. Self-assessment is documented in the published literature as an important skill in developing lifelong learning.[56,115] It is necessary for an assessment to establish whether students are able to assess themselves accurately compared to an expert, in order for the tool to be used exclusively as a self-rated scale.[118] An accurate assessment of performance can also be used as a learning tool, as it enables students to identify their strengths and areas for improvement, thereby promoting future learning. Self-assessment as a teaching tool has been introduced as a method of learning within a competence-based education framework.[22] In recent times, the focus on educational programs has shifted to developing students who are achieving competence as opposed to academic excellence.[150] The reason for this shift was based on feedback from clinicians who reported that new graduates in the health professions possessed appropriate theoretical knowledge however lacked clinical competence, particularly relating to psychomotor skill proficiency. Over the years, teaching techniques and assessment methods have changed in order to reflect the paradigm shift in higher education towards assessing skill competence rather than academic outcomes.[150] Therefore, there has been an increased focus on the development of reliable, consistent, outcome-based assessment of psychomotor performance. In recent years within the context of a competency-based education framework, the deliberate teaching of self-assessment skills has gained momentum.[26,27,151] The teaching of self-assessment skills through reflection and student involvement in the development of learning outcomes is aimed at reducing the Kruger-Dunning effect.[151]

This study compared the students' self-rated scores with the expert rating of the same splint in order to identify the consistency between these scores. The analysis of the data indicated a low correlation between the student and expert scores. Additionally, the researcher found that there was a statistically significant difference between the mean scores of the students and the expert. The published literature in the fields of allied health and medicine further support these findings. The results of two meta-analysis studies of surgical trainees, documented low correlations between the expert and student scores.[117,121] Additionally, the studies found that the participants with the least clinical experience i.e. a novice, were more likely to show a low correlation in scores compared to an expert.[117,121] The authors provided an explanation for this occurrence, proposing that the participants may have not had a thorough understanding of the learning outcomes or underlying principles in order to enable them to accurately self-assess.[118] A study by Dearnley et al.[115], which reported on similar results of poor student-expert correlations, suggested that the students' knowledge of their level of skill is an important prerequisite for future learning and that these findings had a significant impact on the ways universities should tailor their educational programs. Furthermore, Boud et al.[92], in publishing the findings from their study, suggested that formal development in the skills of self-evaluation should be included as an important component of the university curriculum. Tools such as the one developed in the current study could play a role in developing this critical skill.

An alternative justification for the low correlation between the student and expert scores, documented in this study, could be due to the differing expectations of the expert compared to that of the university lecturer in relation to the performance outcomes of the students. For example, the students in this study may have been taught how to construct a splint in a certain way and therefore based their self-evaluation on the university lecturer's standards. On the other hand, the experts who rated the students' splints may have different baseline expectations of splint construction and design based on their clinical experience and training.[64]

In summary, the inconsistency and low correlation between the student-expert scores that have been identified in this study are supported by the published literature.[118] It is widely documented in the published education and surgical literature that there are statistically significant differences between student self-ratings and expert scores, when measuring performance in psychomotor skills.[92,117,118,121]

5.5 The students estimate of their own performance

To answer research question 4, the magnitude of the difference of scores between the students and experts were measured. This study showed that the students in the selected cohort were more likely to overestimate their performance compared to the expert. The mean difference between the expert and student scores varied based on the actual competence of the student. The results indicated that there was a difference between the student and expert scores for those students whose performance ranked in the bottom quartile range, based on the expert assessment.

Conversely, there was no difference between the means of the student and expert scores of those students who performed in the highest percentile. Therefore, the results show there was a greater disparity between the self-assessed skill and actual skill, for those students who performed in the lower quartile range, compared to those that performed in the higher quartile range. This confirms the Kruger-Dunning theory of metacognitive skill development, whereby students who are ranked in the lower range are more likely to over-estimate their performance compared to those with a higher performance ranking.[113]

The finding from this study of the tendency for the lower ranked students to overestimate their performance compared to an expert is supported by the literature. The authors in the published literature hypothesize that the over-estimation of performance is correlated with low levels of competence.[113,114] This psychological phenomenon was documented by Kruger and Dunning[113], whereby they conducted a four-stage study to identify whether incompetent individuals are more likely to overestimate their performance, and whether these individuals lack the metacognitive skills to recognise their ineptitude.[114] Furthermore, a study by Pandey et al[118] compared self and expert scores and found that participants overestimated their performance compared to the ratings of two experts. One study by Kruger et al[113] argues that it is the deficiency in metacognitive skills of novices compared to experts that gives rise to the over-estimation of performance. They go on to hypothesize that the discrepancy between perceived and actual ability can be linked with an unclear understanding of the skill requirements within the task.[113]

The results from this study show that there was a larger discrepancy between student and expert scores for those students who were ranked in the bottom quartile. This shows that the less competent students had a larger difference between perceived and actual ability, than those who performed in the top quartile range. Research studies in the fields of psychology and medicine support this finding, by reporting that the less experienced students are more likely they are to overestimate their performance compared to an expert.[57,113,118,121] Studies from the published literature suggests that the likelihood of overestimating performance may be attributed to the level of experience of trainees, or due to the lack of students' understanding of the learning outcomes.[57,113,121] Within a university and clinical content, the over-rating of performance should be addressed by establishing a clear understanding of the learning objectives, providing opportunities for regular and specific feedback, and encouraging reflective learning opportunities.[47,111] Training programs and clinical supervision should include strategies to teach students how to accurately self-assess.

In addition, Regher et al[97] suggests that in order for self assessment to be effective, the learner must also seek feedback from peers, teachers and clinical supervisors to validate their accuracy in self-evaluation of technical skills.[47,97,111] The published literature reports that by providing specific training in metacognitive skills, such as through practicing logical reasoning and by promoting accurate comparison of performance, accuracy in self-appraisal can improved.[113] Therefore, understanding the direction of the inaccuracy between the student and expert scores can help in the preparation of training programs and provide insight into the type of skills that need further development.[113,121]

Of paramount importance, inaccuracy in self-assessment can have detrimental effects on patient outcomes. For instance, a splint that is moulded in the incorrect position can cause joint contractures and extend the timeframe for rehabilitation.[1,8] If not identified and corrected within a given timeframe, the functioning of a patient and their ability to use their hand can be impaired in the long-term.[8] In clinical environments, graduating therapists often may be working alone or have limited opportunities for supervision and feedback on their technical skill performance.[43] Therefore, it is crucial for these therapists to be able to accurately identify their limitations and areas for improvement.[43]

The importance of receiving accurate and timely feedback has been highlighted in the published literature as an essential component of manual skill acquisition. In a study by Johannesson et al[152] students reportedly valued feedback on their skill performance and this feedback was viewed as an essential component in technical skill mastery. Manual skills are acquired through observation, preparation for a task, practice and repetition and finally through receiving individualised feedback on performance.[152] The feedback on performance can be in the form of a peer or expert assessment or through self-reflection, for example by self-evaluating a task by using a video recording of one's own performance or through comparing self and expert assessments of performance.[65,152] Therefore, administering performance assessments are an essential component of manual skill acquisition and mastery, by providing the necessary feedback to the students in order to achieve technical skill proficiency.[66,152] The orthosis competency assessment designed in this study is therefore beneficial in providing students with the necessary feedback for the development of the skill of upper limb immobilisation orthosis fabrication.

5.5.1 Minimum competence score

In this study, although there was a low correlation between the student and expert scores, all students met the minimum benchmark score to achieve baseline competence. The minimum competence score was calculated by seeking feedback from three experts in the field of hand therapy.[46,90] The experts were asked to assign a minimum score for each item in the assessment rubric. An average score for each item was calculated and then added to achieve an overall score reflecting minimum competence.[94] This finding suggests that the current university programs are adequate in effectively training students to be competent in orthosis fabrication. The published literature reports on the importance of identifying baseline standards for performance in order to identify the minimum level of skill in order to safely perform a task.[90] Although the importance of benchmarking performance has been identified in the literature, there are few studies that describe the minimum level of skill required in order to differentiate between the competent and non-competent individual.[46,89] The current study used appropriate methodology in order to identify a minimum standard to identify competency in orthosis fabrication. The knowledge of student performance can be used to inform university and clinical educators on the success of their teaching programs.

5.5.2 Clinical considerations

The results from the study showed that the difference between the student and expert scores increased when the students assessed their thumb splints, compared to the resting splints. There are two possible explanations for the variation in results between the two different splints. Firstly, the students may have been unclear regarding the expectations of their performance in fabricating thumb splints compared to the resting splints. Secondly, there was a larger number of resting splints collected compared to the thumb splints, and therefore the statistical analysis may be skewed. The author recommends the assessment be re-implemented after further student training on the expectations and learning outcomes of each orthosis to determine if students can improve on their scores.

The author of the current study developed an assessment tool to evaluate competence in immobilisation hand and upper limb orthosis fabrication. The assessment rubric developed for this study has both content validity and clinically acceptable inter- and intra-rater reliability. Currently, there is no published assessment in the search databases to assess generic splinting skills and more specifically, an assessment that subdivides these skills into measurable components to assess a final product. This assessment can be used in clinical and university settings as a standard method of measuring competence in the construction of hand immobilisation orthoses.

5.6 Limitations

The author recognises that there are limitations that need to be considered when interpreting the findings of this study. Firstly, the assessment was designed to measure the final product and not the process of hand and upper limb splint fabrication. The aim of the research study was to develop a valid and reliable assessment of splinting competence that can be applied to a variety of splint types and designs. The process of construction differs based on the type of orthosis design and as a result, the assessment rubric had limitations in its ability to assess the sub-sequential steps in the procedure of splint fabrication. Therefore, the researcher recommends the development of a process-based assessment in order to identify the gaps in skill acquisition at a production level.

Secondly, another potential limitation of this study that has clinical implications is in the development of the minimum competence score of the assessment. The researcher consulted with three experts in order to establish a minimum baseline score to identify competence when administering and scoring the splint assessment. In this study, the experts subjectively scored each criterion based on what they considered to be an essential component of splint design. Therefore, there is an argument that the minimum score for a student to be considered competent is subjective. The research literature suggests further implementation of robust methodologies, in order to effectively benchmark and establish a minimum baseline score for the assessment. This includes methods such as using at least five to six independent experts, or by using a consensus approach whereby the experts submit a round of scores until the mean scores and standard deviations are unchanged between rounds.[93,94]

Thirdly, limitations in regard to the methodology of the study apply to the training of the experts and students about the use of the orthosis competency assessment. In a study by Chapman et al.[153], they found that inter-rater reliability improved after training about the use of their assessment. Furthermore, this finding has been supported in the published medical and education literature.[95,154] In the current study, the limited training may have attributed to the low correlation between the student and expert scores. In the data collection phase, the researcher explained the use of the assessment to the experts and the students, however did not implement a separate training session on its use and its application to the skill of splinting. The experts and students would have potentially benefited from a practice session on the use of the assessment with a generic splint, in order to provide the opportunity for feedback and questions. The session could also include practice with the use of the assessment, by comparing the students' performance to a benchmark splint or working with the researcher to analyse a previously completed assessment on a sample splint. Furthermore, the experts may have benefited from a more comprehensive understanding of the learning outcomes and expectations from the university lecturers about the students' ability to perform within the hand therapy unit. Further training and matching of the university requirements to the expert expectations could also potentially improve the inter-rater reliability.[95]

Fourthly, limitations occurred in the data collection stage of the research study, leading to a reduction in the sample size of participants included in the study. Although the sample and effect size were measured as sufficient to interpret the results and provide clinical significance, the total potential sample size of 240 students was reduced to an actual recruitment size of 82 participant splints due to a multitude of reasons. For example, some students forgot to label their splint, others failed to hand in the completed assessment, and others did not complete the construction of their splints within the given timeframe, in order to enable them to participate in the research study. Furthermore, it was time consuming for the researcher to take photographs of each of the splints in order for them to be included in the study. Some students were unable to wait to complete this step, as they were required to attend other classes. Recruiting an assistant to help take the photographs, to reduce the time required to collect the necessary data, may have reduced the data collection pitfalls.

Furthermore, the researcher could have requested an expert attend the students' laboratory sessions to assess the splints directly after the students completed them. In addition to attending the laboratory practice sessions, the researcher might have scheduled an extra session in order to capture the students who were unable to complete their splint within the allocated class time.

Further limitations occurred in the development of the assessment rubric for splinting competence. The author did not seek beyond the published literature nor contact national or international universities to identify the current assessments being used to assess splinting competence. This was largely due to time constraints. The author would recommend cross-referencing the rubric developed in the current study with assessments used by national and international universities.

Finally, a potential limitation in the ability of the assessment to show competence in splint fabrication is the length of time between instruction and assessment. The researcher assessed the competence of the students immediately following verbal and visual role modeling by the university lecturer. This may not be a true indication of their skill competence in a clinical practice context.[46,90] The question that could be asked is whether the students would still be assessed as competent in orthosis fabrication one or two months after their laboratory practice session? The researcher suggests future research to identify the competence measurement of a student between two or more periods in time. How would the students perform if the splint was fabricated again, a month or so later, and not immediately after instruction from the teacher?

5.7 Suggestions for future research

This research study used quantitative methodology to develop an assessment of competence in orthosis fabrication, taking into account the necessary psychometric properties of measurement. The investigation has made ground in terms of development of an assessment tool that was previously unavailable. However, future research is required to further develop and test the psychometric properties of the orthosis competency rubric and measure its impact in a wider educational assessment context.

The literature suggests that self-assessment skills might be enhanced by providing expert feedback on performance.[118] With this in mind, researchers can repeat the methodology used in this study and extend it further by providing the students with the expert assessment of their performance, thereby allowing them to compare the discrepancy between the results. Thereafter, the same process can be repeated to assess whether the students were able to improve on their self-assessment after receiving the expert feedback.

In the current study, there was a relatively low correlation between the students' self-assessment and the expert scores. To improve on this, a future research project could compare the hand therapy expert scores to university lecturer's scores of student performance in order to identify whether there is a higher correlation between student-lecturer versus student-expert scores. This hypothesis would be based on the theory that the students and lecturers would have similar expectations of the performance outcomes.

Student self-ratings in this study were compared with an expert rating. The education literature suggests that peer assessment can be used as a useful teaching tool and has the outcome of enhancing student performance.[87,155] A future study could include using the orthosis fabrication assessment to compare peer and expert scores and identify whether there is a correlation between the two.

Furthermore, the orthosis competency assessment tool was shown to have a low internal consistency score and therefore, the researcher suggests expanding on the descriptive criteria for each item to improve on the consistency. The same methodology could be applied and a further test of the internal consistency is recommended.

A single assessment of splinting competence does not necessarily provide accurate information on a student's overall competence in splinting skills. Studies have encouraged the assessment of competence in multiple scenarios, to identify the overall skill competence and adaptability of the student.[83] Therefore, the researcher suggests the assessment of splint competence applied to a range of situations (either through role play or real-life scenarios) and also between different types of splints i.e. wrist and thumb.

The importance of setting minimum standards for performance has been discussed in this thesis and therefore the author recommends further research into defining the difference between the baseline and an expert level of competence. This would enhance the assessment's discriminate validity, i.e. the ability of the assessment to distinguish between different levels of performance. A suggested method of achieving this would be to administer the assessment to a number of experts in the field of hand therapy and compare their results to the student's level of performance.

Finally, the researcher suggests a future study to investigate the predictive validity of the orthosis competency assessment tool, to investigate whether competence in one type of splint can predict the competence in another.

The researcher designed a global rating scale that was measured to have moderate inter and intra-rater reliability, and included the necessary methodology to enhance the content validity.

As outlined, the findings from this study suggests that students are not able to accurately self-assess compared to an expert, in relation to competence in orthosis fabrication. These findings are supported in the published literature in the fields of both education and medicine.

Furthermore, the students were more likely to overestimate their performance compared to the expert, which poses a risk in a clinical context, as students may be unaware of their limitations. This could potentially cause harm to patients and impact on their long-term function.

5.8 Summary

In this chapter, the researcher presented a detailed discussion of the findings, with reference to the literature to support these. The limitations of the study were explored and the chapter concluded with the researcher providing suggestions for future research. The next chapter will include a summary of the research study, a discussion of the author's recommendations and the implications of the study on future practice.

6. Chapter Six: Recommendations and Conclusion

6.1 Recommendations and implications for practice

In this chapter, recommendations will be provided for the future implementation of the orthosis competency assessment tool in a clinical and educational context. The recommendations will apply to the use of the orthosis assessment tool developed in this study within a competency-based education framework. Suggestions for methods of improving the metacognitive skills of students will also be included.

6.1.1 Recommendation 1: The orthosis competency assessment tool can be used as an expert-rated assessment tool

The results from this research study have implications for future assessment and training of students, by providing clinical and university educators with a standardised tool to assess competence in hand orthosis fabrication. The orthosis competency assessment was determined to have acceptable levels of validity and reliability. This suggests that the assessment is appropriate for use as an expert-rated assessment in a university or clinical setting, where students are often supervised and evaluated by more than one assessor. The researcher has also determined a minimum score, in order to achieve competence in orthosis fabrication and therefore, the assessment can also be used to calibrate the students' performance against a set standard. Furthermore, the orthosis competency assessment rubric divides subset skills into measurable components. This enables the lecturer or supervising therapist to identify the specific areas of improvement and hence tailor their teaching methods accordingly. The assessment rubric is not recommended for use solely as a self-rated assessment of splinting performance due to the relatively low level of correlation between the student and expert ratings identified in this study.

6.1.2 Recommendation 2: The orthosis competency assessment tool can be used as an instructional tool to improve metacognition

Rubrics can be used as an instructional tool to guide student learning, by providing the students with clarity and transparency regarding the expectations of their performance of a task, skill or behavior.[100,101] The methods of 'reflection in action' and 'reflection on action' have been described as important skills in the development of metacognition i.e. the ability to accurately judge one's own performance, compared to the requirements of the task.[70,116,156,157] The development of metacognition, as a skill in itself, is described as an important addition to the university curriculum, in order to promote the students to become effective self-evaluators. Providing the students with accurate and timely feedback on their performance develops the skill of metacognition.[114,151] The literature suggests that for feedback to be effective it must address three criteria. Firstly, the assessor must be equipped with the knowledge of the standards of a task by subdividing the task into specific and measurable components.

Secondly, the assessor must assist the student to accurately comparing the professional standards to their own performance (against a model or exemplar). Thirdly, the assessor must encourage the student to take action to decrease the discrepancy between the requirements of the task and the student's actual performance by providing opportunities for deliberate practice and altering their performance accordingly, based on the feedback received.[92,116,120,157] Similarly, the orthosis competency assessment tool developed in the current study can be applied to the model of providing effective feedback by giving the students a tool, during the teaching process, which highlights the requirements of the task. For example, the students can rate the splint of an expert, using the orthosis competency assessment, and compare this score to their own splint self-evaluation. The act of comparing their splint to a 'gold standard' using an assessment that divides the skills into measurable components enables the students to accurately reflect on their performance. Therefore, clinical and university educators can use the orthosis competency assessment rubric as an instructional tool in the feedback process in order to enhance the students' metacognition.

6.1.3 Recommendation 3: The orthosis competency assessment rubric can be used to measure the impact of new teaching methods.

The availability of a valid and reliable assessment of competence in orthosis fabrication allows lecturers and clinical supervisors to introduce new methods of teaching; such as simulation and virtual reality, and measure the success of implementing these techniques. The medical, nursing and surgical literature describes the use of simulation and virtual reality in the training of medical students in suturing techniques, surgery, basic life support and critical event management.[57,65-67,69] Simulation has been shown to be an effective teaching method in enabling the students to translate their skills into realistic patient scenarios. Although this format of teaching is documented as being effective in psychomotor skill training, it has not been documented as being applied to the skill of orthosis fabrication. There is a need for such teaching methods to be implemented into the university curriculum for the training of the skill of orthosis fabrication, in order to enhance the students' capacity to apply their skills to a pathological hand.[64] It is predicted in the future that simulation and virtual reality will become a part of the teaching curriculum for educating students in the skill of orthosis fabrication.[12,64] Therefore, a valid and reliable assessment of competence in orthosis fabrication is necessary in order to assess whether the new teaching techniques are effective compared to the traditional approaches. The implementation of the orthosis competence assessment developed in this study will be beneficial in measuring the difference between the traditional and simulation teaching methods.

6.1.4 Recommendation 4: The orthosis competency assessment can be applied to a variety of educational contexts

The orthosis competency assessment was designed as an overall measure of generic splinting competence. It was devised to measure the splinting skills of students for use in different clinical and educational contexts and measuring proficiency of a variety of hand and upper limb splints. Therefore, the intention was for this assessment to be implemented in both university and clinical contexts; i.e. in both simulated and realistic environments. It is recommended that the clinicians and university educators implement this assessment and compare their experiences using the tool, in order to identify whether the students are able to effectively translate their skills into a real-life context. Therefore, it is proposed by the author that the orthosis competency assessment may be able to highlight the gaps, if any, between the university teaching curriculum and the skills applied within a clinical environment.

6.1.5 Recommendation 5: The methodology can be used to develop and design assessments of technical skill competencies and applied to a variety of healthcare fields

The competency assessment that was developed in the current study used multiple validated methods in order to measure technical skill proficiency. The techniques that were applied such as conducting a task analysis and consulting with experts in the field of upper limb rehabilitation were appropriate methods of developing a reliable and valid assessment of the skills of orthosis fabrication. Similar methods can be used by a variety of health care professionals in the fields of medicine, nursing and allied health in order to design an assessment to measure a variety of technical skill competencies. The current orthosis competency assessment can be adapted by other health professionals in an education and clinical context and be useful in providing a structure and format for the development of an assessment of manual skill competency.

6.2 Conclusion

This thesis has presented the results of a research study in which the researcher designed a competency assessment tool in hand and upper limb orthosis fabrication. The study extensively tested the reliability and validity of the developed assessment, and then used it to determine whether students are accurate in identifying their level of performance or competence compared to an expert. The assessment tool was tested with university students who were enrolled in a Bachelor of Occupational Therapy course in Western Australia and who were attending practical laboratory sessions in hand and upper limb orthosis fabrication. Experts, with more than five years of experience in hand and upper limb rehabilitation, were used during the reliability testing stage and again during the final stage of assessing student performance.

Within the context of competence-based education and as a method of promoting lifelong learning, assessments of performance of technical skill should be used for both evaluative and learning purposes[43]. That is, the designed orthosis assessment can be used as an evaluative tool to assess performance within a university and clinical setting, as well as a learning tool to increase the students' awareness and understanding of the subset of skills required to proficiently achieve this skill. Overall, the competency assessment can be used as both a summative and formative assessment of proficiency in the skill of hand orthosis fabrication. The researcher used appropriate methodology to determine the baseline level of performance to achieve competence in hand orthosis fabrication and therefore the tool is valuable in its use as a summative assessment. Furthermore, because the researcher developed the assessment by performing a detailed task analysis, whereby specific skills were subdivided into measureable components, the tool can also be implemented as a formative assessment.

The published literature reports that students are not very successful at being able to accurately calibrate their performance when compared to an expert assessment of performance.[113,117] The results of this study support these findings. The students who performed in the lower percentile were more likely to overrate their performance compared to the expert. On the other hand, the students who ranked in the upper percentile were more accurate in judging their performance, compared to the expert. Therefore, it is recommended that the orthosis competency assessment tool may be beneficial for use by educators, either for assessment purposes or as an instructional tool. As an instructional tool, the assessment can be used to highlight the expectations of the task to the students and therefore assist with future learning. The researcher recommends that educators not use the competency tool purely as a self-assessment, due to the reduced accuracy of students in rating their performance compared to an expert. It is important to note that the skill of self-assessment, much like the skill of motor acquisition, improves with practice. Students should be provided with opportunities for repetitive practice and given feedback on their performance in order to improve their psychomotor skills as well as their ability to self-evaluate performance. Therefore, the orthosis competency assessment can be used as an overall assessment of splinting competence, as well as being used as an instructional tool, in university and clinical settings.

This study was able to address the research questions that were outlined, though with some limitations, as discussed. Further research on reliability and validity testing of the orthosis competency assessment tool is recommended, specifically for use with a variety of splints and for students and new graduates with differing experience in the field of hand and upper limb rehabilitation.

Professional organisations such as Occupational Therapy Australia and the Allied Health Practitioners Regulation Agency, have spearheaded the impetus for professional credentialing and the need for the development of competency standards for health professionals. Health practitioners are expected to prove their competence in different performance domains and therefore the need for assessing competence, in a reliable and valid way, is becoming of increased importance. Furthermore, with the advent of new teaching methodologies in the field of hand therapy, such as virtual reality and simulation, the need for a valid and reliable assessment tool is becoming more significant. The need for the development of valid and reliable methods of assessing competence in hand orthosis fabrication was the motivation for this study. With no published reliable and valid assessment for overall splinting competence available in the literature, the researcher designed and developed an assessment tool for use in university and clinical environments. The orthosis competency assessment rubric will be made available, and published in the future, in order to allow teachers and clinicians to readily access and use it as an assessment and instructional tool.

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8. Appendices

8.1 Appendix 1: The University of Western Australia ethics approval letter

THE UNIVERSITY OF WESTERN AUSTRALIA

Human Ethics
Office of Research Enterprise
The University of Western Australia
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CRICOS Provider Code: 00126G

Our Ref: RA/4/1/7326 — 17 February 2015

Dr Susan Miller
Faculty of Medicine, Dentistry and Health Sciences
MBDP: M515

Dear Doctor Miller

HUMAN RESEARCH ETHICS APPROVAL - THE UNIVERSITY OF WESTERN AUSTRALIA

Developing a Valid & Reliable Tool to Assess Competence in Fabricating Custom Hand Orthoses: Self Versus Expert Assessment

Student(s): Dana-Lee Parkin - Masters - 21173994

Ethics approval for the above project has been granted in accordance with the requirements of the *National Statement on Ethical Conduct in Human Research* (National Statement) and the policies and procedures of The University of Western Australia. Please note that the period of ethics approval for this project is five (5) years from the date of this notification. However, ethics approval is conditional upon the submission of satisfactory progress reports by the designated renewal date. Therefore initial approval has been granted from 17 February 2015 to 01 March 2016.

You are reminded of the following requirements:

1. The application and all supporting documentation form the basis of the ethics approval and you must not depart from the research protocol that has been approved.
2. The Human Ethics office must be approached for approval in advance for any requested amendments to the approved research protocol.
3. The Chief Investigator is required to report immediately to the Human Ethics office any adverse or unexpected event or any other event that may impact on the ethics approval for the project.
4. The Chief Investigator must submit a final report upon project completion, even if a research project is discontinued before the anticipated date of completion.

Any conditions of ethics approval that have been imposed are listed below:

Special Conditions

None specified

The University of Western Australia is bound by the *National Statement* to monitor the progress of all approved projects until completion to ensure continued compliance with ethical principles.

The Human Ethics office will forward a request for a Progress Report approximately 30 days before the due date.

If you have any queries please contact the Human Ethics office at humanethics@uwa.edu.au.

Please ensure that you quote the file reference – RA/4/1/7326 – and the associated project title in all future correspondence.

Yours sincerely

[redacted]

Dr Caixia Li
Manager, Human Ethics

8.2 Appendix 2: Curtin University Reciprocal Ethics Approval letter

MEMORANDUM

Curtin University

To:	Mr Dave Parsons School of Occupational Therapy and Social Work
CC:	
From	Professor Peter O'Leary, Chair HREC
Subject	Reciprocal ethics approval Approval number: HR76/2016
Date	02-May-16

Office of Research and Development
Human Research Ethics Office

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

Thank you for your application submitted to the Human Research Ethics Office for the project: 6282

Developing Valid & Reliable Tool to Assess Competence in Fabricating Custom Hand Orthoses: Self Versus Expert Assessment

Your application has been approved through Curtin University Human Research Ethics Committee (HREC) through a reciprocal approval process with the lead HREC.

The lead HREC for this project has been identified as The University of Western Australia Human Research Ethics Committee

Approval number from the lead HREC is noted as: RA/4/1/7326

Please note the following conditions of approval:

1. Approval is granted from **03-May-16** to **01-Mar-20**
2. Research must be conducted as stated in the approved protocol.
3. Any amendments to the approved protocol must be approved by the Ethics Office.
4. An annual progress report must be submitted to the Ethics Office annually, on the anniversary of approval.
5. All adverse events must be reported to the Ethics Office.
6. A completion report must be submitted to the Ethics Office on completion of the project.
7. Data must be stored in accordance with WAUSDA and Curtin University policy.
8. The Ethics Office may conduct a randomly identified audit of a proportion of research projects app[redacted]

Should [redacted]n of your project please contact the Ethics Support Officer f[redacted]@curtin.edu.au or on 9266 2784. All human research[redacted]n the ethics website.

Yours [redacted]

Profess[redacted]
Chair, H[redacted]

8.3 Appendix 3: Formal feedback questionnaire

Orthosis Assessment – Feedback form

Please complete the orthosis assessment using a splint made by a student or junior therapist, then complete the form below to provide your feedback. You are also welcome to write comments directly on the assessment form for additional feedback.

NoteThe orthosis assessment is comprised of a **checklist** and **global rating scale**. Please use the tabs on the bottom of the Excel document to view these.

After completion, please return this form and any additional comments to myself by **Monday 30th March.**

Usability

1) Approximately how long did the orthosis assessment take to complete? ____________minutes

2) Do you feel this time is appropriate for the tool? YES ☐ NO ☐

If No, please provide suggestions for improvement

____

____

____

____

Language

3) Please comment if you suggest any changes to the language or jargon used to improve ease of reading (note this tool is designed for student use)

____

____

____

____

Layout

4) Please outline below if you suggest any changes to the layout, font or paragraph spacing

____

____

____

____

Content

5) Headings:

a) Do the headings include all the important concepts related to orthosis fabrication?

YES ☐ NO ☐

If No, please explain any additional concepts you feel should be included in the tool:

____

____

____

____

____

b) Are there any headings you would add or remove? YES ☐ NO ☐

If Yes, please explain below:

____

____

____

____

6) Sub-headings and questions:

a) Does the content relate to the headings appropriately? YES ☐ NO ☐

If No, please comment below:

____

____

____

____

b) Is there any more information you would add to the sub-headings/content? YES ☐ NO ☐

If Yes, please explain below:

____

____

____

____

____

Scales

7) Please comment on whether you think the scale of 1-5 and the description within each are specific enough to tell the difference between an incompetent and competent student

____

____

____

____

8) Please add and further comments or suggestions:

____

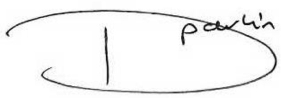
____

____

Once completed, please send this form to dana.parkin@research.uwa.edu.au. Alternatively, you can post it to Dana Parkin, 8/65 Wandarrie Avenue, Yokine, WA, 6060. If you have any questions please contact me on 0412 103 630 or via email.

I sincerely thank you for your time and expertise and am looking forward to your feedback.

Kind Regards,



Dana Parkin

Senior Occupational Therapist

Studying Masters (Research) Health Professional Education at UWA

8.4 Appendix 4: First global rating scale and checklist

Orthosis Fabrication Global Rating Scale

Participant ID # ________________________

Please circle the number corresponding to the candidate's performance based on the splint and photo provided

1	2	3	4	5
Aesthetics				
1	**2**	**3**	**4**	**5**
Orthosis has multiple pen marks, edges are very roughly cut with scissors and finger prints causing indentation. The splint is very imprinted or very overstretched.		Orthosis has one or two small pen marks, no rough edges and may have a small finger print with no indentation.		All orthosis edges are neat and smooth. There are no pen marks and no indentations. Splint is aesthetically acceptable.
Contours				
1	**2**	**3**	**4**	**5**
Volar and dorsal arches are flat and not supported. Straps are not angled for contour.		The orthosis contours to the volar (concave) and dorsal (convex) arches, however one or both are slightly flat in contour. There is very minor potential to cause a pressure area. Straps are not angled for contour.		Volar and dorsal arches are contoured correctly. The orthosis does not have potential to cause pressure areas. Straps are angled for contour to minimise shear stress.
Fit				
1	**2**	**3**	**4**	**5**
The orthosis is incorrectly fitted to the patient. The joints requiring immobilisation are not moulded in correct position. The splint restricts mobility of uninvolved joints.		The orthosis is fitted correctly to the patient. It restricts end range of motion of uninvolved joints. The immobilised joints are in a position within acceptable range.		The orthosis is fitted to the patient correctly. It does not restrict any mobility of uninvolved joints. The immobilised joints are moulded in correct position.
Minimising pressure				
1	**2**	**3**	**4**	**5**

The orthosis does not have adequate surface area to support joints. Bony prominences are not flared. Edges are not rolled or flared. Straps are not wide enough to minimise pressure.		The orthosis has majority of it's surface area to support joints. Bony prominences are flared. Edges may be rolled or flared however there is mild risk of increased pressure on underlying tissues. Straps are not wide enough to minimise pressure.		The orthosis has correct surface area to support joints. Bony prominences are flared. All edges are rolled or flared with no foreseeable risk of pressure on underlying tissues. Straps are correct width to minimise pressure.
Skin Creases / Dual obliquity				
1	**2**	**3**	**4**	**5**
The orthosis impedes all skin creases. It is not angled higher radially than ulnarly (does not follow the anatomical length of the metacarpals).		The orthosis only mildly impedes the skin creases of the hand. It correctly angles higher radially than ulnarly on either the volar or dorsal surface.		The orthosis does not impede skin creases. It correctly angles higher radially than ulnarly on both the volar and dorsal surfaces of the hand.
QUALITY OF FINAL PRODUCT				
1	**2**	**3**	**4**	**5**
Very poor fit and cosmesis		Acceptable fit and cosmesis		Correct fit and cosmesis
TOTAL SCORE GIVEN				**/30**

Orthosis Fabrication Checklist

Instructions to expert assessor: Please circle the number corresponding to the candidate's performance and mark the tool based on the orthosis and photos provided.

Instructions to participant: Fabricate a forearm based thermoplastic orthosis. Complete the questions below to rate your final product.

Name of orthosis:____	Age: ______ _
Splint intended for the following diagnosis: ______________________	Gender: M / F
Completed fieldwork placement in an upper limb setting: YES / NO	

ITEM		Not done, Incorrect	Done correctly
	Form		
1	Appropriate choice of thermoplastic material for orthosis type	**0**	**1**
2	Sufficient surface area to stabilise the joints (if forearm-based - 2/3 length of forearm)	**0**	**1**
3	All Velcro well secured to thermoplastic	**0**	**1**
4	All Velcro secured in the correct position on the splint	**0**	**1**
	Fit		
5	Joints are positioned correctly for intended purpose appropriate for the diagnosis	**0**	**1**
6	The orthosis conforms to contours of the hand – no gaping or indentations on the volar or dorsal surface	**0**	**1**
7	Longitudinal and transverse arches of the hand are supported	**0**	**1**
8	Orthosis immobilises each joint it was designed to immobilise	**0**	**1**
9	Orthoses does not restrict the range of motion of joints it was not designed to impact	**0**	**1**
10	No potential pressure areas caused by the fit of the orthosis	**0**	**1**
11	No sharp edges of the thermoplastic material	**0**	**1**
12	Bony prominences have been flared and/or padded	**0**	**1**
	Aesthetics		
13	No imprints on outside surface of thermoplastic	**0**	**1**
14	All pattern/trim marks have been removed	**0**	**1**
TOTAL SCORE		**/14**	

8.5 Appendix 5: Second developed assessment, a global rating scale

Orthosis Fabrication Global Rating Scale

<table>
<tr><td colspan="5">Please circle the number corresponding to the candidate's performance and mark the tool based on the orthosis and photos provided.</td></tr>
<tr><td>Name of orthosis:______________</td><td>Age:</td><td>Completed fieldwork placement in an upper limb setting: YES / NO</td><td>Gender M / F</td><td>Diagnosis: ____________________</td></tr>
<tr><td colspan="5">Aesthetics</td></tr>
<tr><td>1
Orthosis has multiple visible pen marks</td><td>2</td><td>3
Orthosis has one or two small pen marks</td><td>4</td><td>5
Orthosis has no visible pen marks</td></tr>
<tr><td>1
The orthosis has very roughly cut, sharp edges</td><td>2</td><td>3
The orthosis has one or two small roughly cut edges</td><td>4</td><td>5
The orthosis has smooth edges</td></tr>
<tr><td>1
The orthosis has multiple finger prints</td><td>2</td><td>3
The orthosis has one or two small finger prints</td><td>4</td><td>5
The orthosis has no finger prints</td></tr>
<tr><td>1
The thermoplastic material is very overstretched and uneven in thickness</td><td>2</td><td>3
The thermoplastic material is slightly uneven in thickness</td><td>4</td><td>5
Thermoplastic material is not overstretched and is even in thickness.</td></tr>
<tr><td>1
Velcro is very poorly secured to the splint, causing corners to come away and/or easily pulled off.</td><td>2</td><td>3
Most of the Velcro is secure, with only one or two small edges coming away from the splint.</td><td>4</td><td>5
All Velcro is firmly secured to the splint.</td></tr>
<tr><td colspan="5">Contours</td></tr>
<tr><td>1
Volar and dorsal arches are flat and not supported.</td><td>2</td><td>3
The orthosis contours to the volar (concave) and dorsal (convex) arches, however one or both are slightly flat</td><td>4</td><td>5
Volar and dorsal arches are contoured correctly and well supported</td></tr>
</table>

		in contour.		
1 Straps are not angled for contour	**2**	**3** One or more straps are angled for contour however may be slightly incorrectly angled.	**4**	**5** Straps are angled correctly for contour.
Fit				
1 The orthosis does not immobilise any of the joints it was designed to immobilise	**2**	**3** The orthosis adequately immobilises one or more of the intended joints.	**4**	**5** Orthosis fully immobilises each joint it was designed to immobilise
1 The orthosis is moulded so that all joints are in an incorrect position for the diagnosis.	**2**	**3** The orthosis is moulded in an acceptable position for the diagnosis. (e.g. one joint may be slightly too flexed, extended or deviated but considered non-harmful for the diagnosis.)	**4**	**5** Orthosis moulded so that all joints are in the correct position for intended purpose
1 The splint completely restricts motion of two or more uninvolved joints.	**2**	**3** The splint restricts only end range of motion of less than two uninvolved joints.	**4**	**5** The splint does not restrict any mobility of all uninvolved joints.
1 Incorrect choice of thermoplastic for diagnosis	**2**	**3** Acceptable choice of thermoplastic for diagnosis	**4**	**5** Ideal choice of thermoplastic material for diagnosis.
Minimising pressure				
1 The orthosis does not have adequate surface area to support joints.	**2**	**3** The orthosis has majority of its surface area supporting joints.	**4**	**5** The orthosis has correct surface area to support joints.

1	**2**	**3**	**4**	**5**
The orthosis has multiple folds and/or indents with a high risk of potentially causing pressure areas. Bony prominences are at high risk of pressure.		The orthosis has one or small folds with a low to mild risk of developing a pressure area. Bony prominences have a minimal risk of pressure.		The orthosis has no folds or indents with no potential risk to cause pressure areas. Bony prominences are padded and/or flared with no risk of pressure.
1	**2**	**3**	**4**	**5**
The splint has insufficient surface area to support the required joints.		The splint has sufficient surface area to support joints however may be a slightly too long or short.		The orthosis has the correct surface area to support joints (if forearm-based - 2/3 length of forearm).
1	**2**	**3**	**4**	**5**
Straps are not wide enough to minimise risk of pressure areas		Most straps are sufficient width to minimise pressure.		All straps are the correct width to minimise pressure.
1	**2**	**3**	**4**	**5**
All Velcro straps are in an incorrect position on the splint		Most Velcro straps secured in the correct position on the splint		All Velcro secured in the correct position on the splint.
Skin Creases / Dual obliquity				
1	**2**	**3**	**4**	**5**
The orthosis impedes all skin creases.		The orthosis only mildly impedes the skin creases of the hand.		The orthosis does not impede any of the skin creases.
1	**2**	**3**	**4**	**5**
The orthosis is not angled higher radially than ulnarly (does not follow the anatomical length of the metacarpals).		The splint angles higher radially than ulnarly on ***either*** the volar or dorsal surface.		The splint correctly angles higher radially than ulnarly on ***both*** the volar and dorsal surfaces of the hand.
TOTAL SCORE				**/90**

8.6 Appendix 6: Final orthosis fabrication competency assessment

Orthosis Fabrication Competency Assessment

Please circle the number that best corresponds with your performance in making a custom splint.

Name of orthosis: ________________________	Diagnosis of patient: ______________________	Age: ________
	Gender: **M / F**	Completed fieldwork placement in an upper limb setting: **YES / NO**

	Aesthetics		
1	**1** Orthosis has multiple visible pen marks	**2** Orthosis has one or two small pen marks	**3** Orthosis has no visible pen marks
2	**1** The orthosis has very roughly cut, sharp edges	**2** The orthosis has one or two small roughly cut edges	**3** The orthosis has smooth edges
3	**1** The orthosis has multiple finger prints	**2** The orthosis has one or two finger prints	**3** The orthosis has no finger prints
4	**1** The thermoplastic material is very overstretched and uneven in thickness	**2** The thermoplastic material is has one or two small areas of uneven thickness	**3** Thermoplastic material is not overstretched and is even in thickness
	Velcro and strapping		
5	**1** The hook Velcro is very poorly secured to	**2** Most (two or more) of the hook Velcro is	**3** All hook Velcro is firmly secured to the splint

	the splint, causing corners to come away and easily pulled off	secure, with only one or two small edges coming away from the splint	
6	**1** Insufficient number of straps to secure splint to client's hand	**2** The splint has enough straps to secure it to the hand however, may have too many straps	**3** Correct number of straps to secure splint to client's hand.
7	**1** **None** of the straps are wide enough to minimise risk of pressure areas	**2** Two or more straps are sufficient width to minimise pressure	**3** **All** straps are the correct width to minimise pressure.
8	**1** **None** of the Velcro straps are secured in the correct *position* on the splint	**2** Two or more Velcro straps are secured in the correct *position* on the splint	**3** **All** Velcro is secured in the correct *position* on the splint.
	Contour/Fit		
9	**1** Volar (concave) and dorsal (convex) arches are flat and not supported. Incorrect contouring to both arches	**2** The orthosis contours to the volar and dorsal arches, however one or both are slightly flat in contour	**3** Volar and dorsal arches are contoured correctly and well supported
10	**1** The orthosis **does not** immobilise any of the joints it was designed to immobilise	**2** The orthosis is acceptable in immobilising one or more joints it was	**3** Orthosis **fully** immobilises each joint it was designed to immobilise

			designed to immobilise (but may allow slight movement at these joints)	
11		**1** The orthosis is moulded so that all joints are in an **incorrect position** for the diagnosis	**2** The orthosis is moulded in an **acceptable position** for the diagnosis (e.g. one joint may be slightly too flexed, extended or deviated but considered non-harmful for the diagnosis)	**3** Orthosis moulded so that **all** joints are in the **correct position** for the diagnosis
12		**1** The splint completely restricts motion of two or more uninvolved joints	**2** The splint restricts only end range of motion of less than two uninvolved joints	**3** The splint does not restrict any mobility of uninvolved joints
13		**1** Incorrect choice of thermoplastic for diagnosis	**2** Acceptable choice of thermoplastic for diagnosis	**3** Ideal choice of thermoplastic material for diagnosis
		Minimising pressure		
14		**1** The orthosis does not have adequate surface area to support joints. (E.g. has a surface area of	**2** The orthosis has the majority of its surface area supporting joints. (E.g. has a surface area of more	**3** The orthosis has correct surface area to support joints. (E.g. has surface area of 2/3 or more of the forearm)

	less ½ of forearm)	than ½ of forearm)	
15	**1** The orthosis has multiple folds and/or indents with a high risk of potentially causing pressure areas and bony prominences are at high risk of pressure	**2** The orthosis has one or small folds with a low to mild risk of developing a pressure area and bony prominences have a minimal risk of pressure	**3** The orthosis has no folds or indents with no potential risk to cause pressure areas and bony prominences are padded and/or flared with no risk of pressure
	Skin Creases / Dual obliquity		
16	**1** The orthosis impedes all skin creases	**2** The orthosis impedes 30% or less of the skin creases of the hand	**3** The orthosis does not impede any of the skin creases
17	**1** The orthosis is not angled higher radially than ulnarly (does not follow the anatomical length of the metacarpals)	**2** The splint angles higher radially than ulnarly on ***either*** the volar or dorsal surface	**3** The splint correctly angles higher radially than ulnarly on ***both*** the volar and dorsal surfaces of the hand
	TOTAL SCORE		**/51**

Key:

Orthosis – splint or brace

Volar – palm side of hand

Dorsal – back of hand

Radial – towards the radius bone

Hook Velcro – rough adhesive Velcro

Ulnar – towards the ulna bone

Loop Velcro – a soft non-adhesive strap that attaches to the hook Velcro.

8.7 Appendix 7: Participant information forms

THE UNIVERSITY OF WESTERN AUSTRALIA

Participant Information Form (Student)

Dr Susan Miller

Education Centre

Faculty of Medicine, Dentistry and Health Sciences

The University of Western Australia, 35 Stirling Hwy (M515), Crawley 6009

Email: sue.miller@uwa.edu.au Phone: 6488 6894

Student Researcher

Mrs Dana Parkin

8/65 Wandarrie Avenue, Yokine, WA

Email: dana.parkin@research.uwa.edu.au Phone: 9224 2133

Developing a valid and reliable tool to assess competence in fabricating custom hand orthoses: self versus expert assessment

Dear Participant,

My name is Dana Parkin and I am a currently doing my Masters by Research at The University of Western Australia in the field of Health Professions Education. I have an interest in upper limb assessment, particularly in orthosis evaluation. I am conducting a research study to develop an orthosis evaluation tool, which can be used in practical settings to improve the quality of splints made by students and novices. In this study, I will be developing and testing the reliability and validity of the tool.

Background

More importance is being placed on developing competence in the area of hand splinting and at present there is limited published literature on a reliable and valid tool to assess this skill.

Aims

The aim of this study is to develop a reliable and valid competency tool to assess skills in orthosis fabrication at a novice level and identify whether there is a difference between student self-rating and expert assessment scores.

Methods

The study will involve three stages. In Stage 1, I will develop the tool and consult hand therapy experts to validate it. Stage 2 will involve testing the reliability of the tool between five expert assessors. In stage three the tool with be used by students and experts in order to compare the results. Your involvement is requested in Stage 3, where you will be required to complete the splint evaluation tool based on one splint you have made in your upper limb workshop. It should take 10- 15 minutes to complete. You will also be required to send in the splint, together with two photos (the back and front) of it secured onto the hand it was moulded for. The splint and photos will be anonymously given to an expert assessor who will use them to complete a separate orthosis evaluation tool.

Participants

I aim to recruit occupational therapy students from two universities in WA who are currently completing upper limb splinting workshops. Participation in the research study is voluntary and you are free to withdraw at any time.

Data analysis

Once all completed forms are received, I will analyse the data to compare student and expert scores, and test whether they are consistent.

Information management

Everything sent to me will be assigned a number to ensure anonymity, and will be stored in a locked filing cabinet and will be returned to you at the end of the study. All other information related to the study will be kept in a secure filing cabinet for 7 years. Participation in this study will have no bearing on your grades for the unit.

Your lecturer will be blinded to the results of the study until after completion.

If you wish to participate please complete the Participant Consent Form and return it to me. One copy is for you to retain. If you have further questions regarding the study please contact me.

Thank you in advance for being a part of my research study. Kind Regards,

Researcher: Dana Parkin Masters by Research Health Professions Education University of Western Australia Dana.parkin@research.uwa.edu.au 0412103630

Approval to conduct this research has been provided by the University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time. If you have any queries or concerns, please contact the Chief Investigator, Dr Susan Miller phone 64886894.

In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Ethics Office at the University of Western Australia on (08) 6488 3703 or by emailing to humanethics@uwa.edu.au

All research participants are entitled to retain a copy of any Participant Information Form and/or Participant Consent Form relating to this research project.

8.8 Appendix 8: Participant consent forms

THE UNIVERSITY OF WESTERN AUSTRALIA

Participant Consent Form

Chief Investigator

Dr Susan Miller

Education Centre

Faculty of Medicine, Dentistry and Health Sciences

The University of Western Australia, 35 Stirling Hwy (M515), Crawley 6009

Email: sue.miller@uwa.edu.au Phone: 6488 6894

Student Researcher

Mrs Dana Parkin

83 Lonsdale Street, Yokine, WA 6060

Email: dana.parkin@research.uwa.edu.au Phone: 9224 2133

I, (the participant), have read the information provided and any questions I have asked have been answered to my satisfaction. I agree to participate in this activity, realising that I may withdraw at any time without reason and without prejudice.

I understand that all identifiable information that I provide is treated as strictly confidential and will not be released by the investigator in any form that may identify me. The only exception to this principle of confidentiality is if documents are required by law.

I have been advised as to what data is being collected, the purpose for collecting the data, and what will be done with the data upon completion of the research.

I agree that research data gathered for the study may be published provided my name or other identifying information is not used.

Participant name: ________________________ Signature: _______________ Date: ______________

Approval to conduct this research has been provided by the University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time.

In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Ethics Office at the University of Western Australia on (08) 6488 3703 or by emailing to humanethics@uwa.edu.au

All research participants are entitled to retain a copy of any Participant Information Form and/or Participant Consent Form relating to this research project.