Chapter 6

Interactive Practices in a Library Makerspace Using Technology to Deliver Positive Student Outcomes

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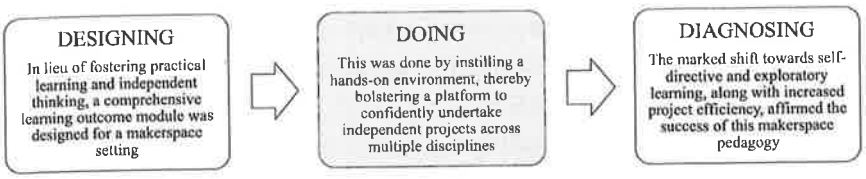

Preamble

With her chapter, Henriette van Rensburg contributes to the book, *Enhancing Student Learning Outcomes in Higher Education*, by describing how an academic library makerspace contributes to a university's innovation culture. She relates to the three phases of the central ESLO model of the book in this way:

The DESIGNING phase revolves around the conceptual blueprint of detailed learning outcomes. A creative ecosystem, an academic library makerspace, is designed to foster an atmosphere of innovation and practical learning within the university. The planned outcomes primarily aim to inculcate essential skills that adult learners can utilise effectively within this makerspace setting, ensuring a comprehensive learning approach.

In the DOING phase, the strategy developed in the earlier phase is executed within a practical learning environment. The application of these learning outcomes into the makerspace creates a propensity for learners to apply their skills and confidently undertake independent projects. The implementation also reveals potential implications and benefits for the varying stakeholders involved, providing a tangible perspective on the learnt skills.

Within the DIAGNOSING phase, a careful evaluation of the successful transition to output-based curricula and the effectiveness of the implemented learning outcomes takes place. There is a critical assessment of the traditional grading system's relevance in the face of rapidly advancing artificial intelligence technologies. Also, a noticeable shift of learners' preference towards a self-directed and exploratory approach to learning is reflected. These highlight the overall effectiveness of the innovative approach implemented within the university.

Introduction

A makerspace is an environment where lecturers, researchers and students can get together *"to share resources and knowledge, work on projects, network, and build"* (Educause, 2013). I define learning outcomes as 'the need to know', including the skills adult learners learn within the makerspace setting, allowing them to use equipment and undertake projects more independently and confidently than before. In addition, this chapter has the potential implications and benefits of the research findings for educators, administrators, and policymakers. All such stakeholders are interested in enhancing student learning outcomes in higher education using makerspaces *and* other innovative learning environments that provide suitable facilities and support for learning; an ecosystem that includes the activity and the learning outcomes.

In the current global knowledge-intensive population, the need for higher education has become more prevalent, both for individuals and societies (Altbach et al., 2019; Information Resources Management Association, 2022). Higher education educators *"want students to achieve the educational, societal, and life effects that result from students being educated"* (The Glossary of Educational Reform, 2014:1). How can we improve students' learning outcomes in higher education? Ludwig et al. (2017:33) identified in their study that STEM (Science, Technology, Engineering, Mathematics) students learning outcomes improved *"when engaging in makerspace activities by creating tangible solutions to health-related problems"*. They discovered these students could identify and learn capabilities that will be critical in their future work.

Student outcomes usually refer to the expected goals of a learning experience, course, or program; they can also refer to the actual grades

they achieve or fail to achieve during their education or later in life (The Glossary of Educational Reform, 2014). Lock et al. (2020:5) echo this by stating that *"risk-taking and learning from failure are critical components of making"* and learning. The Covid-19 pandemic challenged many educators and universities to respond to the challenges by changing and adapting in many ways to serve this changing world (Altbach et al., 2019). Halverson and Sheridan (2014) emphasised the emerging role of *making* in education. Learning occurs when learners make concrete artefacts through real-life learning and authentic opportunities and it is a creative and collaborative way to transform teaching and learning (van Rensburg & Piper, 2019). UNSW Art & Design Australia (2015) emphasises that their makerspace is an environment where students are no longer just consumers but can direct the learning outcomes themselves.

This study provides a snapshot of how a makerspace can play a key role in enhancing students' learning outcomes in a multi-campus regional university in Queensland, Australia. This type of project-based learning is often called 'constructivist learning', an idea developed by the educational psychologist, Papert (Blikstein, 2013). He believed that learning is best done from experiences, through building a physical object or something shareable with others; this is especially effective when the project is chosen by the student and self-directed (Yusoff & Aziz, 2020).

At the library makerspace, we often receive a wide range of specific requests from students and staff regarding personal projects, research or within different curricula. They learn hands-on skills with our latest digital fabrication technologies, at their own pace and to their own interest. Makerspace staff members want students and staff to feel confident with digital fabrication technologies for independent use. Benefits include capable and high-achieving graduates who, with admirable portfolios, prove to be more innovative and thus more employable.

Chapter overview and key takeaways

In Section 1, I describe the background to our work on enhancing students' learning outcomes in the university library makerspace and education areas, and examine the underpinning learning theory — Knowles' theory of andragogy. Following this, in Section 2, I demonstrate our project-based practice towards enhancing student learning outcomes focussing

on how our practice affects students' way of studying, and outlining the qualitative methodology used, namely the visual elicitation method, to ascertain our findings. Section 3 is where I present the findings of the study in the outcome section, from the perspectives of students, staff and the author; using Knowles' six concepts of andragogy to categorise the findings. Section 4 looks forward to possible future expansion of the university library makerspace, with a greater amount of physical space for use in curricular spanning a broader variety of subject areas. I conclude the chapter by re-iterating the value of makerspace in successfully engaging students in many different areas of tertiary study.

Reading this chapter, three insights will be gained:

1. The value of incorporating Malcolm Knowles' six principles of Andragogy (Knowles, 1984) into a library makerspace;
2. The importance of learner-centred, as well as problem-centred, project-based challenges for enhancing student learning outcomes; and
3. How a library makerspace can play a key role in building students' confidence, experience, orientation to learning, motivation and independence.

Section 1: Background to our work with learning outcomes

As an experienced university educator in Technology Education, I am interested in andragogy and the importance of the students' learning journeys. In this research project, I worked closely with the Community Engagement Coordinator, running the library makerspace at the university. The Coordinator contributes significantly to developing a research and evidence-based library culture and work collaboratively to support decision-making and service improvement. This includes practice-based research in the university library makerspace. The Coordinator and I also collaborate with other educators, curriculum designers and researchers to ensure that the makerspace activities align with students' learning outcomes and support their academic development.

There is a connection between university activities and improving

students' skills development. Data from the 3D printer usage in the makerspace during the past three months indicated 1,000 printing activities. Each 'print' also often contains multiple parts, activities or jobs, and this number shows the incredibly high demand for the makerspace 3D printers. There is often a waiting list for machine time during the semester. The university library makerspace is a place for hands-on learning with equipment including 3D printers, 3D scanners, laser cutters, electronics and more. *"Going beyond the physical location itself, they centre around building and creating in a collaborative environment"* (Bell et al. 2023:1). All students and staff members from any study area and faculty can use the space daily during weekdays between 10 am to 2 pm and undertake projects within research, course curriculum or extra-curricular areas. To begin their experience in this area, participants receive free 3D prints of up to 500 grams, where they can choose to print something from thingiverse.com or myminifactory.com. They learn how to set up a 3D print in the slicing software, change the printing material and set up the 3D printer. Generally, students choose something extra-curricular to print, which is low-pressure and encourages elements of play.

After completing a combination of online and hands-on inductions, students can obtain swipe card access to the makerspace between library opening hours (weekdays from 8 am to 6 pm and weekends from midday to 5 pm). This allows students to work independently on their projects within the makerspace. The goal is to build capacity in the students, allowing them to work unaccompanied and confidently. Rather than operating a printing space for students to send jobs to without interacting with the equipment, the focus is on skill building, not on the project output.

The makerspace allows students to gain hands-on skills that may not be present in their studies and receive one-on-one instruction for hands-on skills that they would otherwise not receive in a standard class. This allows students to undertake projects in their own interest areas and create portfolio projects that make them more employable upon completing their studies. The makerspace also acts as a 'third place' outside work or home where students can meet others and learn together, often sparking serendipitous collaborations across study areas, students, staff members and the public. Bogue and Ouillon (2023) describe makerspace third spaces as increasing social connectedness and building

community, providing support in times of crisis. Through their research, Bogue and Ouillon (2023) experienced the evolvement of the Fab Lab into a more general community facility, offering advice and support on various issues and a space for people to talk, socialise, and share skills and knowledge. University makerspaces *"represent an opportunity for interdisciplinary access to technology and resources for digital fabrication and varied creative projects…however, a gap in the research literature on makerspaces on university campuses, including within libraries"* (Bell et al., 2023:1). Indeed, many researchers note the need for empirical research on the role of makerspaces in the Australian higher education context (Baker, 2021; Bell et al., 2023; van Rensburg & Piper, 2019; Wong & Partridge, 2016).

The university library makerspace staff members also experience challenges and face obstacles in the daily conducting of the makerspace. Sometimes it is difficult to find technical personnel to run the space. Competent staff and assistants are equally as important as the equipment; a successful and sustainable makerspace cannot function with just one and not the other. Although students and staff are offered safety inductions and guidance on the correct equipment usage, the university staff members are always aware of the level of risk when operating in the space. A part of developing hands-on skills in a makerspace is accepting that this is always a low-risk environment for participants. Makerspace users must accept some level of risk to reap the benefits of learning hands-on skills. It needs to be a safe learning space where students are allowed to fail. Sometimes a student can initiate a 3D print job incorrectly, which can damage the equipment or cause a print failure. Accepting that this can happen, and preparedness for mitigating these problems, is key in allowing students to fail and keep going with the learning experience.

Learning theory and methodology related to learning outcomes

In more traditional pedagogy, education is viewed as a passive *"transmittal of knowledge and skills that had stood the test of time"* (Knowles, 1970:40). Yet, Knowles' theory of andragogy, which is based on self-directed independent learning, is philosophically opposed to such a behaviorist approach, and developed into a kind of movement within academia. Savićević (1991) noted that the research body revolving around

andragogy has also expanded, and related research since has continued to develop (for example Knowles et al., 2015; Tezcan, 2022). As an educator, I follow the adult learning principles associated with andragogy (Knowles, 1990; Knowles et al., 2015) to underpin the development of the university library makerspace and when conducting the workshops. This theory-informed pedagogical approach improved students' outcomes and can be achieved by better application of skills, improved job performance, increased self-value, active and increased engagement in learning. The need for a different learning approach to pedagogy became obvious in reaction to the global societal changes that required adults to learn to their own advantage and with an instantaneous ability to apply what was learned (Savićević, 1991). The adult learning theory is based on Kolb's (1984) experiential learning, whereby learning is engrained by doing (Cherry, 2022). Adult learners are *"encouraged to explore the subject matter firsthand and learn from their mistakes. As a result, they are less likely to make those mistakes in the workplace and continually develop their experiential knowledge"* (Pappas, 2013). Successful adult learning is rooted in the basic principles that steer adult learners, namely, *"an acknowledgement of the knowledge and experience gained by adult learners and the idea that the learner — and not the instructor — is central to the process"* (Conaway & Zorn-Arnold, 2016:38). Such self-directed, independent learning is reflected in Knowles' (1984) six concept approach to adult learning, namely andragogy, and is the theoretical framework that underpins this study.

1. Experience

Conaway and Zorn-Arnold (2016) described two elements of experience, namely, time and dimension, experience being the mental re-creation and outcome of time past; it can also interpret the present and predict the future. Learners can draw meaning from both physical and/or psychological past experiences. Conaway and Zorn-Arnold (2016) further stated that educators can provide hands-on experience, for example, makerspace projects and science experiments. Adult learners rely on their own experiences as a framework for growth, they learn by integrating past experiences with new concepts and interpreting them in new, meaningful ways. Moreover, as Pappas (2013) notes, *"as a person matures, he/she accumulates a growing reservoir of experience that becomes an increasing resource*

for learning". Stewart (2021) extends this in her belief that adults' existing knowledge bases and life experiences make them more likely to be sceptical of new information- they learn best by challenging and testing new ideas.

2. Self-directedness

Self-directedness refers to the ability of an individual to make autonomous choices and decisions and to take full responsibility for their outcomes, it is a skill that develops with experience and age (Conaway & Zorn-Arnold, 2016:39). Self-directed learning *"empowers adults to adapt accordingly to fluid and complex social contextual changes...and advantages of fostering self-directed learning competence avoidance of knowledge and skill obsolescence"* (Morris, 2019:57).

3. The learners need to know

Adult learners become aware that they need to know more skills and information to reach their goals. They want to know why information is important (Conaway & Zorn-Arnold, 2016). Adult learners already know the benefits of learning. At the same time, Bloomquist and Georges (2022:59) described it as *"an intricate combination of identities, practices, and outcomes used to prepare people to address complex problems".* Margitay-Becht and Das (2023 in this book) also note that their students needed to be interested in the course to be motivated and successful: *"the students read the syllabus, including the course descriptions and learning outcomes, and select a class that they find appealing".*

4. Readiness to learn

Often there is a high failure rate among beginner students when they do not realise the importance of working hard. They are successful when they realise that an incident has motivated them to take control of their lives and has led them to enrol in university (Mikheeva et al., 2021; Conaway & Zorn-Arnold, 2016; Omar et al., 2020).

5. Orientation to learning

Adult students see the future as now; their alignment with learning is learner-centred (versus teacher-centred) and problem-centred, where they can apply what they are learning (Conaway & Zorn-Arnold, 2016).

6. Intrinsic motivation

Pedagogy focuses mostly on children and is situated in an extrinsically motivated environment, where the learner's behaviour is driven by a reward (Ozuah, 2005). In most countries, children are obliged to attend school, whereas adults study because they want to, due to personal growth and development. According to Morris (2019), adults are motivated by their needs, personally meaningful values, and interests when pursuing their goals. Students incorporate the critical principles of andragogy of goal orientation, self-direction, and intrinsic motivation and embrace a more active learning role (Caldwell et al., 2020).

Section 2: Our practice towards enhancing student learning outcomes

University makerspaces are characterised by a user base that includes students and staff from any discipline. The university library makerspace is a vibrant hub of activity, hosting workshops, and a place where staff and students use makerspace equipment for projects, curriculum classes and industry placement projects. It fosters spaces where students can work on open-ended projects within their curriculum and as extra-curricular projects have many benefits. With the rise of AI text generation and ChatGPT-style technology, the way educators assess and grade learning outcomes are debatable. Assigning grades can have detrimental effects on the priority of the learning outcome versus the number received, and research indicates three reliable effects when students are graded- they tend to think less deeply, avoid taking risks and lose interest in the learning itself (Kohn, 2006). Challenge and project-based learning is more engaging for students and focuses on the process rather than the outcome (Kohn, 2006).

There is a growing movement for 'ungrading' in tertiary education. Stommel (2021) made the case that grades only are not a good incentive, feedback or marker of learning. They also encourage competitiveness over collaboration and do not reflect the idiosyncratic, subjective, emotional character of learning and are not inherently fair. Conaway and Zorn-Arnold (2016) stated that for adult learners, the future should be learner-centred, not teacher-centred. Learning is no longer an act of depositing, whereby students are the depositories and the teacher a

depositor. This results in a lack of creativity and transformation; knowledge only emerges through invention and re-invention, arguing for a project and challenge-based approach. Makerspaces will very likely become more common with a shift in focus to project-based learning as educators evolve away from graded learning that is too easily replicated with AI technology tools.

How our practice affects students' way of studying

Project-based activities undertaken in the university library makerspace include the industry placement subject program, where students can pair with a local business and the makerspace to create a 3D printed or electronic solution to a problem. For example, students may create a custom learning aid for the science department, in their area of interest, or collaborate with a local hand therapy business on developing an aid for a client with a disability. These problem and solution-based projects are chosen with the student's desired career pathway in mind, tailored to their interests and inspirations. The final project is duplicated for the client and the student to keep, allowing the student to build up a portfolio of projects that aids in future employment.

A current student is working with the local hand therapy business to create a dexterity trainer for clients to increase proprioception and re-train muscles. In consulting with the hand therapist and the makerspace manager, she has created a list of minimum deliverables for the project. Using iterative design principles, the student learns how to utilise Autodesk Fusion 360 software, creating a 3D model from a sketch concept. After multiple rounds of client feedback, 3D printing and design improvements, the final product is delivered to the hand therapist and made available as an open-source download on the makerspace website. These types of projects benefit the university and local community and equip students to work independently with digital fabrication technologies, gaining a powerful problem-solving skillset.

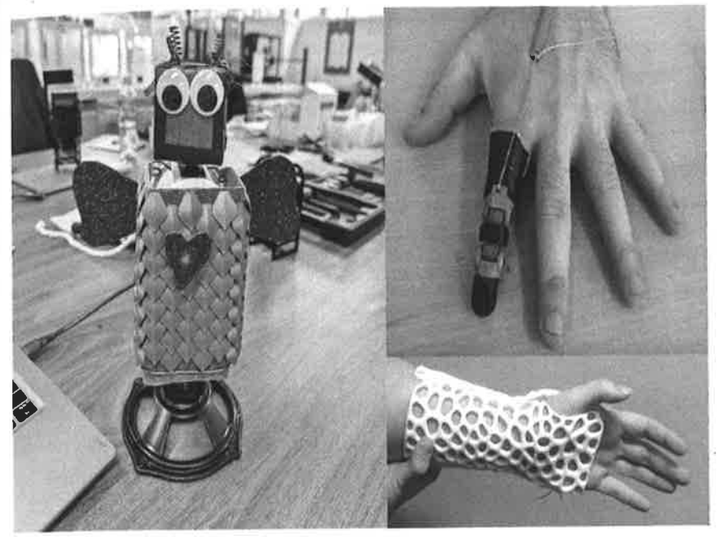

Figure 1: Snapshots from the makerspace.

The university library makerspace also offers a variety of workshops, including 3D Printing Basics, Arduino and Electronics, Autodesk Fusion 360 Basics, how to build a website and more. The Built a Bot two-day workshop is a project-based session where participants can design and build their own robot character. Using two servo motors and an LED light, they can make a creature of their own design come to life. This session combines the 3D printing and Arduino workshops to form a workshop intensive where students can take ownership of their project and learning and also take home their own creations. This workshop often receives glowing reviews, and sessions are held for university students, staff, and local teachers as professional development sessions.

A new makerspace workshop, the Future Makers Entrepreneurship Workshop, has recently been introduced at the university. This runs one day a week for three weeks to introduce students to basic business skills and side hustles. Many students are interested in solving problems or starting their businesses but do not have the skills to get started. This workshop uses the Lean Startup Methodology to test business ideas with

the least monetary investment possible, focusing more on customer validation and time investment. This workshop has also received excellent reviews from participants.

Evidence of learning outcomes in the university library makerspace is collected from multiple sources. The qualitative evidence presented in this chapter has been developed from a research case study, in addition to user feedback and observations from the library staff within the makerspace. This case study research undertaken in the library makerspace sought an interpretive understanding of users' experiences of participation. This was a qualitative study that responded to two research questions:

- How do university makerspace adult users actively engage with the space and its activities to enhance their learning outcomes?
- What can adult users own experience of participation tell us about the value of using the makerspace for research, course curriculum, and extra-curricular as a framework for growth underpinned by andragogy?

The study employed a visual research method during the data collection phase to explore users' insights. Visual methods in qualitative research rely on visual mediums, such as photographs, to create data and meaning. The method chosen was a visual elicitation method (Orr et al., 2020), similar to photo elicitation and photo voice methods, including a visual element in our methodology aligned with the nature of the makerspace itself, as the makerspace is a tactile and hands-on environment that involves visual outputs. A purposive and convenience sample was used in this case study, with participants selected based on their sustained use of the makerspace for course curriculum, extra-curricular, or research purposes.

Four semi-structured interviews were conducted, with three student participants and one academic staff member. Two student participants had been introduced to the makerspace through their coursework and proceeded to do professional placements within the makerspace. A third student used the makerspace for extra-curricular projects, which included personal projects and community-based volunteering work. The thirty minutes interviews were conducted online via Zoom. These participants were invited to share visual media to describe their makerspace

use at any stage. This could include photos, objects, designs, or any other visual media. It provided a unique way for participants to participate in the interview and share work that was meaningful to them and how they engaged with the space. Throughout the interviews, the visual research method helped to guide conversations about projects and the context in which they existed. The shared objects and visual media also provided the opportunity for reflection during the interviews. This helped the participants to connect the outputs of individual projects to the skills, knowledge, and support that had contributed to them.

Section 3: The outcome – perspectives of student, staff and the author

University ethical clearance was given before the original research started. Four semi-structured interviews were conducted via Zoom, with three student participants and one academic staff member. In this case study, the author was given permission to analyse the pre-existing data set. All the excerpts below are from the student participants taken from the pre-existing data set, unless otherwise indicated, for example (Staff participant).

Experience

Stewart (2021) claimed that adults' existing knowledge bases and life experiences make them more likely to be doubtful of new information, they learn best by testing new ideas. Burke (2015) stated that problem-based learning problems and activities are excellent ways for students to build and strengthen their knowledge. Yet, often students and staff in our study experienced initial hesitancy or apprehension in using the university library makerspace. This was coupled with curiosity and a feeling of wanting to be involved and experience what was on offer:

- *and not being able to go in there without…thinking that I'm intruding… to be honest, I thought it was…like part of the Creative Arts…and I didn't really have anything to do with it for a long time".*

In addition, an academic staff participant felt more confident in the development of his own skills:

- *"We just started off really simple, and then, probably about six months later, I bought my own 3D printer"* (Staff participant).
- *"And I've always been a problem solver, I think that's in my nature. And I'm crafty as well. So it has really, it's just, it's given me so much more to do with that, which has been really great"* (Staff participant).

Thus, the participants' initial hesitation changed to being confident makerspace users.

Self-directedness

A mature learner's self-concept moves from:

> *"one of being a dependent personality toward one of being a self-directed human being…Since adults are self-directed, instruction should allow learners to discover things and knowledge for themselves without depending on people. However, learners should be offered guidance and help when mistakes are made"* (Pappas, 2013).

The willingness of makerspace users to share expertise created a positive and participatory environment. Adult learners are inclined to descend more toward learning experiences that offer some sort of social development benefit (Pappas, 2013). There was an understanding that:

- *"everyone that goes in there is willing to help everyone and listen to what you're doing and give you their ideas".*

Makerspace provided an opportunity to develop social and reciprocal connections based on a shared interest and experience. This allowed for connection outside of one's own academic program, encouraging input in projects from students with different academic backgrounds and new sources of expertise and knowledge. Thus, the makerspace may be conceived as an informal social learning space where students can meet new people. Some students responded that the makerspace is:

- *"a place to meet up with other likeminded students wanting to make things"*
- *"I mean, you go in with the idea of what you want to do but being able to bounce the ideas off (the coordinator) or if she's not there, another*

person that's in there. Yeah, collaborative, you know, getting everyone's opinion".

Irrespective of whether discussion and problem-solving were collaboration, this sharing of knowledge and community was described by all student participants. The makerspace was experienced as a site of community connection. Being able to *"bounce ideas off"*, *"get input"*, or receive *"ongoing advice from peers or the coordinator"*. Furthermore, one student participant described how, as a science student, *"talking to someone that's an engineering student that I really wouldn't cross paths with otherwise at the university. That's really nice"*.

The learners need to know

Bouchrica (2023:1) clearly stated that *"adult learners have the need to know the value of what they are learning and know the why's behind the need to learn them"*. Sometimes a barrier to participation included understanding the purpose of the makerspace. Students using the makerspace recognised its value in contributing to their skills development. One student who had undertaken their course placement in the makerspace expressed the value of what was learnt: *"It really has been invaluable — it's given me a whole new set of skills"*. Importantly, comments from other students identified the need to know the value of their learning:

- *"Initially, I went into this thinking I would do pre-med and go into med…or even research, but this has taught me a lot about how technology and science really work together to create things that really help people".*
- *"I didn't expect this to now be such a big part of my life, where you know, nearly every day I'm thinking about what I can print, what I can design, what, how I can make something better for, for my son, for my husband, for my parents for gardening, and like I can make a tool for that. Yeah, it's made a huge difference, and I didn't think it would".*
- *"So it really has changed and had a big impact on so many different parts of my life".*
- *"So it's not something that you can see a lot in the space right now in that space that I work in. So having that element of technology in*

science and seeing how everything works out is, like, really cool".

Thus, the participants became aware that they needed to gain more skills and acknowledged the benefits of hands-on learning.

Readiness to learn

Adult learners usually fund their own learning or are sponsored by their employers; they still study by choice and are ready to learn. This makes them more attracted to study (Pappas, 2013). Students responded as follows:

- *"I use the space as a way of taking a new perspective on things".*
- *"So it's given me a lot of hope in my life decisions in a way to help me see that what I've done in my placement it is something that I could do in the future".*
- *"...going from an idea, translating it onto the computer, and then getting something physical at the end".*
- *"I learned how to take, take basically an idea from your head, or maybe like a little sketch that you've drawn, turn it into a model on the computer, and then turn it into something physical that, you know, now I've got, and I can work with".*
- *"Now I come home, and I have a whole new take on problem-solving... around the house".*
- "It's *led me to where I have now, with my honours".*

In this way, the above participants acknowledged the importance of working hard to be successful. They realised that taking part in maker-space activities of their own choice motivated them while they took control of their learning and lives.

Orientation to learning

For adult learners, the orientation to learning is for immediate use rather than future application. The learning orientation of adults tends to incline towards focusing on the problem or the cause of why a problem emerged (Bouchrica, 2023). Students and a staff member responded as follows:

- *"My accommodation doesn't have much in space other than some hanging space. So I made a piece that can go onto a hanging line that interlocks...it's designed so it can easily hold any pots and pans or such".*
- *"I didn't want to damage anything in the place I'm renting. And I want something that would both fit but also be both easily reusable, easily modified".*
- *"For work, a lot of it is just about improving productivity...Like they're not exciting things, but they make our work projects just go a little bit better".* (Academic participant)
- *"...to be honest, I was just like, I just need to get this placement out of the way so I can graduate".*
- "I'm *very study driven...so it was driven by placement and studies. So...not really driven by creativity, unfortunately".*

These comments clearly indicate that the participants saw the future as now, and that their alignment with learning was learner-centred and problem-centred, where they could apply what they were learning.

Intrinsic motivation

Adults are more motivated by internal personal factors rather than external pressures. Intrinsic motivation gives adult learners choices instead of making an activity a requirement. The following excerpts from the student participants expressed their intrinsic motivation:

- *"And then [the Coordinator, Community Engagement] had mentioned that you could do a couple of free prints as a student. So there were a few of us that were, like, some awesome stuff. Let's go back and find something...then that was how it started".*
- *"I tend to use the space as a way of taking a new perspective on things. That's actually why I came up with the design... for the hanging hook...".*
- *"I wanted to go back because I was excited for it. But you know, seeing the 3d printers and all the stuff she has there. It's a little bit like...I'm not gonna know how to do this".*

These comments demonstrate that the participants engaged in the library makerspace activities because they wanted to, due to personal growth and development. The 'Build a Bot' workshop is a two-day, project-based workshop where participants can design and build their own robot character. Some of the student participant feedback for this session included the following:

- *"This course was really challenging, I am so glad I came along. I am a little bit amazed that I learnt how to do (what I consider) to be pretty hard stuff. Thank you for supporting the development of my self-efficacy. I really achieved some great success. Even more importantly, I actually have developed the crazy belief that I can do it, I have enough base knowledge to get started to develop further I can actually do robotics!".*
- *"The design thinking activities were truly transformative for my practices. Your task was extremely engaging, open-ended and supported me to use my creativity and reflective thinking. I don't think I would have gained the knowledge I have now if I had not been able to explore and experience like you supported us to do".*
- *"This workshop I was so nervous about because it was like nothing I had ever done before. But thanks to you I did get it, I understood, and I feel much more confident teaching these curriculum objectives and cross-curriculum priorities now. I feel as though I could now Including more learning using the same framework in different curriculum areas".*

Thus, although the participants found the workshop challenging and engaging, they learnt from the hands-on experience and became confident in their own skills and abilities.

The Future Makers Entrepreneurship Workshop is a business-skills focussed session where students learn lean start-up methodology to create their own business or side hustle. Feedback from this session included the following:

- *"My favourite part of the workshop was the lean methodology to figure out MVP and 'see how it sticks' attitudes. Allows me to try lots of things but know how long to try before moving on".*
- *"Thank you very much for doing this. It has opened my mind up to different opportunities and ways of thinking. I have more confidence to try different things with the lean methodology".*

These findings are parallel to those of van Rensburg and La Thanh (2021:149), who also found that *"students tend to have a positive attitude toward using technology"*. The skill-sets gained by the students in our study sit within the categories of Knowles' theory of andragogy (Knowles, 1984), and they are:

- Experience
- Self-directedness
- The learners need to know
- Readiness to learn
- Orientation to learning
- Intrinsic motivation

Thus, the study has shown the value of incorporating Knowles' six principles of Andragogy into a library makerspace to develop students' skills and attributes as learning outcomes.

Section 4: Moving forward

Makerspaces are agents of change influencing how educational stakeholders conceptualise learning, how they engage in designing and facilitating learning, as well as how technology is used in teaching and learning (Peterson & Scharber, 2018). Along with the venture into the infrastructure to support and enhance student learning and outcomes, the university library makerspace strives for the best possible design and to facilitate authentic learning experiences. Through illustrative examples, makerspace staff seeks to acknowledge strategies and challenges encountered in supporting robust learning through making. Lock et al. (2019:9) echo this by stating: *"Design and creativity are making their way to the forefront of educational considerations, and Makerspaces can address the needs of the future"*. van Rensburg and Piper (2019:14) also note the benefit of including and combining makerspace activities in adult education: *"Makerspace can be used by all educators and students...and it is a creative and collaborative way to transform teaching and learning...with many beneficial and positive effects for all the stakeholders"*. These exemplifications tie in with Knowles' (1984) six-concept approach to adult learning, namely

experience, self-directedness, the learners need to know, their readiness to learn, their orientation to learning, and intrinsic motivation as student learning outcomes.

Ludwig et al. (2017:33) identified that STEM students in their study achieved their *"course objectives when engaging in makerspace activities by creating tangible solutions to health-related problems"*. Their students could recognise and learn capabilities — as their learning outcomes — that will be significant in their future work. This links to the future expansion of the university library makerspace, where there will be more physical space for curriculum engagement across a wider variety of subjects with different equipment available as the space expands. For example, food science students may use food 3D printers, or future materials research students may be able to use the makerspace to try out new plastic recycling techniques. A larger makerspace will benefit all the stakeholders across the university community, allowing for organic cross-collaboration and serendipity in networking and learning. More leadership positions will soon be available for students, allowing them to teach other makerspace users skills and gain more advanced skills. Having students as partners with makerspace skill delivery will make it more accessible for new first-time users and should give the space a closer connection to respond to users' needs.

In future, there may be more interplay between vocational studies and tertiary studies, bringing together hands-on skills with the technical and theoretical aspects as the world becomes more integrated with online connectivity, IoT (internet of mymini) and automation.

Conclusion

We have shown in this chapter that makerspace can successfully engage students in many different areas of study within higher education. Makerspace hands-on activities improve students' skill development and eventually allow them to work unaccompanied and confidently. It can assist in empowering motivated, self-directed, and experienced adult learners and educators to achieve positive outcomes in self-chosen activities whenever they are ready for this hands-on learning. Makerspace gives students the opportunity to gain skills and experience that may not be part of their curriculum, yet make them more employable upon

completion of their studies. Makerspace can be use
outside classes, work or home where participants c
learn together. New collaboration across study areas
and the public can be formed to increase social cor
community. Interactive practices in makerspace requi
between educators and students using technology to deliver excit
and positive outcomes for all participants. Following Malcolm Knowles'
six-concept approach to adult learning, andragogy is the underpinning
framework of this chapter: 1) experience, 2) self-directedness, 3) the
learners need to know, 4) readiness to learning, 5) orientation to learning,
and 6) intrinsic motivation contributed to practices that derived positive
learning outcomes for all. The findings of this study could successfully
be applied to many different disciplines in higher education. Experiential
learning, the process of learning by doing, is used to connect theories and
knowledge to real-world situations. We conclude by stating that learning
and *"life is a journey, not a destination"* (Branch & Wernick, 2023 in this
book).

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I acknowledge the contributions of Stephany Piper for sharing her knowledge and expertise, which has helped me to write this chapter. She is the Community Engagement Coordinator, running the Library Makerspace at the University of Southern Queensland.

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Bibliography

Altbach, P, G., Reisberg, L., & Rumbley, L.E. (2019). *Trends in global higher education: Tracking an academic revolution.* (Vol. 22). Brill.

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completion of their studies. Makerspace can be used as a 'third place' outside classes, work or home where participants can meet others and learn together. New collaboration across study areas, students, academics and the public can be formed to increase social connectedness and build community. Interactive practices in makerspace require interaction between educators and students using technology to deliver exciting and positive outcomes for all participants. Following Malcolm Knowles' six-concept approach to adult learning, andragogy is the underpinning framework of this chapter: 1) experience, 2) self-directedness, 3) the learners need to know, 4) readiness to learning, 5) orientation to learning, and 6) intrinsic motivation contributed to practices that derived positive learning outcomes for all. The findings of this study could successfully be applied to many different disciplines in higher education. Experiential learning, the process of learning by doing, is used to connect theories and knowledge to real-world situations. We conclude by stating that learning and *"life is a journey, not a destination"* (Branch & Wernick, 2023 in this book).

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Bibliography

Altbach, P, G., Reisberg, L., & Rumbley, L.E. (2019). *Trends in global higher education: Tracking an academic revolution.* (Vol. 22). Brill.

Baker, A. H. (2021). *Exploring student perspectives on informal and formal learning in university makerspaces* [Doctoral thesis, Clemson University]. TigerPrints.

Bell, E., Piper, S., & O'Sullivan, C. (2023). Users' experiences in a regional academic makerspace: a case study. *Journal of the Australian Library and Information Association, 72*(2)135-149.

Blikstein, P. (2013). Digital fabrication and' making' in education: the democratization of invention. In J. Walter-Herrmann & C. Büching (Eds.), *FabLabs: Of machines, makers and inventors*. Transcript Publishers.

Bloomquist, C. D., & Georges, L. (2022). Interdisciplinary leadership: A leadership development model for scholar-practitioners. *Journal of Leadership Education, 21*(4), 58-75.

Bogue, K., & Ouillon, S. (2023). Third place social infrastructure, after and in crisis: Insights from a local case study. *Global Social Challenges Journal, 1* (aop), 1-18.

Bouchrika, I. (2023). *The andragogy approach: Knowles' adult learning theory principles*. Retrieved July 3, 2023, from https://research.com/research/what-is-empirical-research

Branch, J. D., & Wernick, D. (2023). The use of debate cases for enhancing students' reasoning skills as learning outcomes. In K. Enomoto, R. Warner & C. Nygaard (Eds.), *Enhancing student learning outcomes in higher education*. Libri Publishing Ltd.

Burke, J. (2015). *Making sense: Can makerspaces work in academic libraries?* Paper presented at ACRL 2015, March 15-18, 2015. Advancing Learning Transforming scholarship Association of College & Research Libraries.

Caldwell, K. L., Vicidomini, D., Wells, R., & Wolever, R. Q. (2020). Engaging patients in their health care: Lessons from a qualitative study on the processes health coaches use to support an active learning paradigm. *Global Advances in Health and Medicine, 9*, 1-9.

Cherry, K. (2022). *Learning by doing. This is the basis for the experiential learning theory*. Retrieved July 3, 2023, from https://www.verywellmind.com/experiential-learning-2795154

Conaway, C., & Zorn-Arnold, Barbara. (2016). The keys to online learning for adults: The six principles of andragogy. *Distance Learning, 12*(4), 37-42.

Educause. (2013). *7 things you should know about Makerspaces*. Retrieved July 3, 2023, from https://library.educause.edu/resources/2013/4/7-things-you-should-know-aboutmakerspaces

Glossary of Educational Reform (2014). *Student outcomes*. Retrieved July 3, 2023, from https://www.edglossary.org/student-outcomes/

Halverson, E. R., & Sheridan, K. M. (2014). The maker movement in education. *Harvard Educational Review, 84*(4), 495-504.

Information Resources Management Association (2022). *Research Anthology on Remote Teaching and Learning and the Future of Online Education* (4 Volumes). Retrieved July 3, 2023, from https://www.irma-international.org/open-access/

Knowles, M. (1984). *Andragogy in action: Applying modern principles of adult learning*. Jossey-Bass.

Knowles, M. (1970). *The modern practice of adult education: From pedagogy to andragogy*. The Adult Education Company.

Knowles, M. (1990). *The adult learners: A neglected species*. Gulf Publishing Co.

Knowles, M. S., Holton, E. F., & Swanson, R. A. (2015). *The adult learner: The definitive classic in adult education and human resource development* (8th ed.). Routledge.

Kohn, A. (2006). The trouble with rubrics. *English Journal, 95*(4), 12-15.

Kolb, D.A. (1984) *Experiential learning: Experience as the source of learning and development*. Prentice-Hall, Inc.

Lock, J., Gill, D., Kennedy, T., Piper, S., & Powell, A. (2020). Fostering learning through making: Perspectives from the international maker education network. *International Journal of E-learning & Distance Education, 35*(1), 1-26.

Ludwig, P. M., Nagel, J. K., & Lewis, E. J (2017). Student learning outcomes from a pilot medical innovations course with nursing, engineering, and biology undergraduate students. *International Journal of STEM Education, 4*(1), 33-14.

Margitay-Becht, A., & Das, U. (2023). Enhancing student learning through hidden motivational learning outcomes. In K. Enomoto, R. Warner & C. Nygaard (Eds.), *Enhancing student learning outcomes in higher education*. Libri Publishing Ltd.

Mikheeva, M., Schneider, S., Beege, M., & Rey, G. D. (2021). The influence of affective decorative pictures on learning statistics online. *Human Behavior and Emerging Technologies, 3*(3), 401-412.

Morris, T. H. (2019). Adaptivity trough self-directed learning to meet the challenges of our ever-changing world. *Adult Learning, 30*(2), 56-66.

Omar, H., Khan, S., Haneline, M., & Chooi Gait Toh, C.G. (2020). Attitudes of dental and chiropractic students towards a shared learning programme – an interprofessional learning model. *European Journal of Dental Education, 25*(3), 592-599.

Orr, E. R., Ballantyne, M., Gonzalez, A., & Jack, S. M. (2020). Visual elicitation: methods for enhancing the quality and depth of interview data in applied qualitative health research. *Advances in Nursing Science, 43*(3), 202-213.

Ozuah, P. (2005). First there was pedagogy and then came andragogy. *Einstein Journal of Biology and Medicine, 21*(2), 83-87.

Pappas, C. (2013). *The adult learning theory – andragogy – of Malcolm Knowles.* eLearning Industry. Retrieved April 29, 2023, from https://elearningindustry.com/the-adult-learning-theory-andragogy-of-malcolm-knowles

Peterson, L., & Scharber, C. (2018). Learning about makerspaces: Professional development with K-12 inservice educators. *Journal of Digital Learning in Teacher Education, 34*(1), 43-52.

Savićević, D. M. (1991). Modern conceptions of andragogy: A European framework. *Studies in the Education of Adults, 23*(2), 179-201.

Stewart, H. (2021). The secret to making adult learning stick? Make it all about you. *Training & Development, 48*(4), 28-30.

Stommel, J. (2021). *Ungrading: An introduction.* Retrieved July 3, 2023, from https://www.jessestommel.com/ungrading-an-introduction/

Tezcan, F. (2022). Andragogy or pedagogy: Views of young adults on the learning environment. *International Education Studies, 15*(1), 136-147.

UNSW Australia, Art & Design. (2015). *The campus makerspace.* UNSW Australia.

van Rensburg, H., & La Thanh, T. (2021). Impacts of using technology-enhanced language learning in second language academic writing at a Vietnamese university. In K. Enomoto, R. Warner & C. Nygaard (Eds.), *Teaching and learning innovations in higher education.* Libri Publishing Ltd.

van Rensburg, H., & Piper, S. (2019). *Enabling students to learn hands-on technical skills using makerspace in a higher education academic library.* Conference Proceedings 2019- Singapore Learning Design and Technology Conference 1-8.

Wong, A., & Partridge, H. (2016). Making as learning: makerspaces in universities. *Australian Academic & Research Libraries, 47*(3), 143-159.

Yusoff, A. S. M., & Aziz, N. N. (2020). Conceptualisation of School Makerspace to Support Constructivism and Project-Based Learning in Public Schools in Malaysia. *Journal of Advanced Research in Social and Behavioural Sciences, 21*(1), 53-74.