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Create, Innovate, Play and Explore: Opportunities for Formal and Informal Teaching and Learning in Makerspaces in Ireland

ABSTRACT

The Maker Movement has gained in popularity over the last decade, allowing people of all ages and with varying skills and abilities to come together in order to create and explore in areas such as art, science, and engineering. To facilitate this movement, for profit companies, non-profits, and educational institutions run makerspaces. This qualitative study set out to examine the benefits of makerspace adoption in higher education in Ireland, with particular attention to their pedagogical value. The authors sought to identify opportunities for teaching and learning and the development of rich, diverse, and inclusive educational environments, as well as the potential to develop a maker network linking tertiary makerspaces with the wider community. Nine administrators from diverse types of makerspaces participated in interviews where they described the impacts and observed effects of makerspaces on participant learning experiences. Findings indicate that makerspaces support self-directed and peer learning, foster inclusive learning communities characterised by skill-sharing and mentorship, and provide safe environments for experimentation and productive failure. In doing so, makerspaces support learning dispositions such as agency, resilience, and self-efficacy, which are increasingly recognised as critical to student learning, persistence, and adaptability in contemporary higher education. Participants also perceived positive impacts on mental health, an area that remains under-researched in tertiary makerspaces. Finally, interviewees advocated for the development of a maker network in Ireland, suggesting that such a network could facilitate the sharing of skills and resources and strengthen access to larger-scale funding.

KEYWORDS

creativity, learning environment, collaboration, experiential learning, tertiary education

INTRODUCTION

Research on learning spaces highlights the influence of physical and social environments on student engagement within higher education (Oblinger 2006). Scholarship of teaching and learning (SoTL) literature has similarly emphasised the importance of learning conditions such as agency, partnership, and belonging for student success (Felten and Lambert 2020). Makerspaces offer a practical context in which we can examine the design of learning environments and the conditions that support learning together. They provide opportunities for experiential learning, peer

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collaboration, and iterative problem-solving, positioning learners as active participants rather than passive knowledge recipients. For educators unfamiliar with makerspaces, examining how these environments function pedagogically provides insight into how to structure learning so it promotes curiosity, resilience, collaboration, and a sense of belonging—outcomes that are strongly associated with student persistence and success in higher education. Framing makerspaces in this way positions them not simply as sites of technical production, but as pedagogical environments that cultivate learning dispositions such as resilience, curiosity, and self-efficacy. These dispositions are central to preparing students to engage with uncertainty, complexity, and ongoing change in higher education and beyond.

Makerspaces are places (both physical and digital) that facilitate creative production in art, science, and engineering for people of all ages, enabling for the exploration of ideas, the learning of new skills, and the creation of products (Sheridan, Halverson, Litts, Brahms, Jacobs-Priebe, and Owens 2014). The Maker Movement has gained a great deal of momentum in the past decade from researchers and the public (Sheridan et al. 2014; Van Holm 2015). Spaces have grown and developed independently. Different institutions refer to them by a variety of names, including makerspaces, hackerspaces, and fab labs, but according to Van Holm (2014; 2015), the differences between these spaces are not signified by the official name, and thus we can use "makerspace" as an umbrella term to describe all such spaces. For the purposes of this research, we use "makerspace" to offer a similarly broad view and to incorporate spaces where individuals and groups can create, innovate, experiment, and play with a range of equipment, technologies, and materials. Thus, the definition used in this paper incorporates self-named makerspaces, fab labs, hackerspaces, community organisations, and artist collectives.

For the purposes of this study, formal learning refers to structured educational activities that are institutionally situated and often linked to predefined learning outcomes, curricula, or assessment practices. Informal learning, by contrast, refers to learning that is self-directed, interest-driven, and embedded in social participation, even when it occurs within institutional settings. We acknowledge that these distinctions may blur in practice, particularly within higher education contexts where staff, faculty, and students increasingly value co-curricular and extra-curricular learning. However, these terms provide a useful analytical lens for examining the range of teaching and learning practices evident within makerspaces.

This qualitative study reports the teaching and learning in makerspaces in Ireland, the implications and opportunities for makerspaces within higher education, and the benefits for greater collaboration among makerspaces at local, county, and national levels.

Teaching and learning in makerspaces

In recent years researchers have explored the potential of makerspaces as places for teaching and learning across all levels of education and in diverse institutions, including schools, universities, libraries, and museums (Bilandzic 2016; Caballero-Garcia and Grau-Fernandez 2019; Jones, Cohen, Schad, Caratachea, and Smith 2020; Meyer 2019; Sheridan et al. 2014; Taheri, Robbins, and Maalej 2019). Makerspaces engage learners in experiential learning, peer collaboration, and rapid iteration. In higher education, studies link makerspace participation to gains in self-efficacy, design attitudes, and sense of belonging, which are key predictors of persistence and learning (Andrews, Borrego, and Boklage 2021; Hilton, Tomko, Murphy, Nagal, and Linsey 2018).

Makerspaces in higher education have the potential to enhance learning experiences and support effective teaching. These spaces facilitate experiential learning, foster communities of practice, and boost self-efficacy through social learning (Meyer 2019; Taheri et al. 2019). In some

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disciplines, such as engineering and design education, learning activities in makerspaces can help learners bridge the gap between theory and practice (Brahimi, Khalifa, and Benaouda 2019). Studies indicate that makerspace curricula positively impact students' creativity, critical thinking, collaboration, and communication skills (Meyer 2019; Wilczynski, Wigner, Lande, and Jordan 2017).

Indeed, many researchers, teachers, and educators have identified makerspaces as a potential forum to revolutionise teaching and learning, as they foster opportunities for hands-on acquisition of skills such as problem-solving, critical thinking, collaboration, and communication (Kurti, Kurti, and Fleming 2014; Sheffield, Koul, Blackley, and Maynard 2017). Furthermore, makerspaces can provide alternative or complimentary education; are part of the infrastructure for developing skills for the future; have a central role in fostering innovation, ideation and prototyping; and can inspire individuals to create their own job or business (Ferretti, Guimarães Pereira, Panella, Ross, and Wanner 2017).

The Irish context

In their 2017 study, Ferretti et al. found that Ireland ranked 13th overall among the 28 EU countries in terms of number of makerspaces. However, when measured in terms of makerspaces per million inhabitants Ireland ranked seventh out of 28, which is substantially higher. Like in its European counterparts, the Irish maker movement includes activities related to electronics, programming, robotics, 3D printing, fabrication, woodwork, metalwork, arts, and crafts (Ferretti et al. 2017).

Ireland hosts a variety of makerspace types with differing operational structures. Makerspaces may exist within a school, university, industrial park, library, or community centre. Some facilities may be purpose-built; others may take advantage of unused space within a larger organisation or a local authority may provide a space. There are both for profit and not-for-profit makerspaces. Makerspaces are often funded by private memberships, event or programme fees, and government schemes. Private member donations or direct purchases may help supply equipment and materials (Ferretti et al. 2017).

Although no in-depth nationwide study has been conducted since 2017 and there has been no comprehensive attempt to quantify participation at a national level, available evidence suggests that maker activities in Ireland remain active and locally embedded. For example, Thompson's (2021) review of makerspace provision in Dublin highlights ongoing and planned initiatives across organisations, universities, and local authorities, indicating continued interest and investment at regional and institutional levels. More recent developments, such as targeted funding awards for makerspaces within Irish higher education, further suggest sustained engagement with maker approaches, even in the absence of a coordinated review (Mary Immaculate College 2024). The absence of a more recent nationwide study may reflect the decentralised and grassroots nature of the maker movement in Ireland, where activity is distributed across community organisations, libraries, and educational institutions rather than coordinated centrally. While the present study is small in scale and exploratory in nature, it responds to this gap by offering qualitative insight into how makerspaces are experienced and understood within Irish higher education, contributing contextualised evidence to an area that remains under-examined. Indeed, as enthusiasm for makerspaces across Ireland has grown, research-based insights into the potential role of makerspaces within contemporary teaching and learning practice will make an important contribution to their future integration within higher education.

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AIM OF THE STUDY

With this study, we aimed to explore the potential opportunities for teaching and learning in a range of makerspaces across Ireland, looking specifically at the following research questions to inform our investigations:

1. To what extent do makerspaces provide opportunities for teaching and learning, specifically within higher education?
2. How might makerspaces provide a more rich, diverse, and inclusive environment for teaching and learning within higher education?
3. Are there any synergies or benefits to aligning makerspaces in higher education with those in the wider community?

METHODOLOGY

While makerspaces can be found in educational, commercial, and community settings, the present study focused on those most likely to inform higher education practice. As we undertook the research to inform an appropriate model for higher education, we deemed standalone makerspaces and those in tertiary institutions as most relevant. We identified potential participants by examining makerspace websites across Ireland and utilising contacts from the MakerMap Steering Group, established by researchers at University College Cork. The university's Research Ethics Committee provided ethical approval for this project in early 2020.

We sent a recruitment email to all potential participants detailing the nature of the study. The email assured potential participants that their data would be anonymized and provided the opportunity to speak with the researchers about the project before agreeing to participate.

The final list of interview participants featured nine managers or directors representing makerspaces from various locations in Ireland. We selected makerspace managers and directors for this study due to their longitudinal perspective on learning practices across diverse participant groups and activities. As we designed this research as a qualitative study, these perspectives provided insight into patterns of teaching, learning, and community formation that may not be visible from single-course or single-cohort viewpoints. Table 1 organizes the makerspaces by affiliation and states their primary focus. We used pseudonyms in order to protect anonymity.

Table 1. Participants: Types of makerspaces

Classrooms, colleges, and universities	Standalone operations, community organisations, and collectives
Jesse Sam	Alex (Art) Pat (Woodwork, small construction projects) Shea (Art) Charlie (Art) Jude (Art) Drew (Art) Kris (Community making projects and entrepreneurial incubator)

We conducted semi-structured interviews to explore attributes of Irish makerspaces. The team developed the interview questions in relation to the study's aims and informed by gaps identified in the literature concerning how higher education uses makerspaces for teaching and learning, particularly in the Irish context. In line with qualitative research guidance, the interview

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schedule prioritised a small number of open-ended questions in order to elicit rich, detailed responses and to allow participants' perspectives to shape the direction of the discussion (Creswell 2007; Tisdell, Merriam, and Stuckey-Peyrot 2025). Questions focused on how interviewees used makerspaces for teaching and learning, how learning occurs within these spaces, and how makerspaces interact with institutional and community contexts. This approach supported close attention to participants' meanings and experiences of managing makerspaces, while ensuring that the data collected addressed the study's research questions and remained open to unanticipated themes. Due to COVID-19 restrictions, we scheduled interviews via email and held them on Zoom between June and August 2020. A dictaphone recorded interview audio. No video was recorded.

DATA ANALYSIS

A third party and software professional transcribed the interviews in order to facilitate organisation and analysis; we deleted recordings after transcription and assigned pseudonyms at the same time. We used the Framework Method, as described by Gale, Heath, Cameron, Rashid and Redwood (2013) and shown below in Figure 2, to organise the data and prepare it for analysis.

Figure 2. Framework approach (Gale et al. 2013)

Stage 1: Transcription
Stage 2: Familiarisation with the interview
Stage 3: Coding
Stage 4: Developing a working analytical framework
Stage 5: Applying the analytical framework

Authors 1 and 3 independently coded the same two transcripts to generate an initial set of analytical codes. We then compared our coding, discussed areas of convergence and difference, and agreed on the codes and their definitions to develop a working analytical framework (Gale et al. 2013). Using inductive analysis (Thomas 2006), we derived themes solely from participant data. We then applied the working framework to the remaining transcripts and revised it to incorporate any new codes that emerged. Finally, we systematically applied the agreed framework across the full dataset.

Results

Once we identified themes, the team employed thematic analysis, informed by Braun and Clarke (2006), in order to interpret the data and compile findings. Three global themes emerged: formal education, informal education, and future directions. Each global theme comprises a number of subthemes, as detailed in Table 2.

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Table 2. Themes and subthemes

Formal education	Informal education	Future directions
Subthemes: Research and experimentation Workshops Continual professional development	*Subthemes*: Collaborative learning (Skills sharing and mentorship) Environment Exploration/failure	*Subthemes*: Makerspace network Sustainability Inclusivity Community outreach Incubator

Theme 1: Formal education

Formal education in makerspaces can encompass specific projects that are tied to educational institutions or workshops that are designed for a specific learning outcome. The data indicated that when tied to an institution like a university, students or research groups that are applying or experimenting with a specific theory or knowledge to achieve a defined output utilised makerspaces. This type of learning may build upon a formally taught curriculum in a classroom and may include an assessment where students are asked to create something, give a presentation, or to assemble a project portfolio. Sam, who managed a makerspace at an Irish university, stated they had "a lot of structured education happening." He worked with the school of art, the school of architecture, and even a local church and other institutions and groups in the city. Furthermore, Sam made the makerspace available to independent third parties who offered courses in jewellery or other types of making. In such courses, learning may not be an end in itself, but they increase makerspace membership and raise awareness among the community of the resources available to them.

Similarly, other managers used their makerspaces for continual professional development (CPD) offering one-off or recurring workshops to facilitate the acquisition of a relevant skill by makerspace participants. For example, Alex, who manages a makerspace for sculptors, offers workshops in business practices for artists; Jude, whose space is also primarily used by artists, requires its members to "host workshops and share skills with the wider community." Jesse, who manages a university's makerspace, stated that research groups "do quite a lot of community engagement" offering courses in 3D printing and other types of making.

In both cases, though learning may be more formal, interactions are more natural and informal with facilitators providing guidance when necessary. Jesse stated that they bought specific equipment to meet project needs. "Lecturers were assigning video projects. . . Many students used phones, [and] the makerspace ordered tripods for video stabilisation. . . and then a 360-degree camera, which is really cool. . ." The benefits to learning and exploration were not limited to the one assigned project. "If they sit down and it's a semi-structured environment, they can play around with something," Jesse observed, "and if they have some guidance then they are going to be more comfortable and come back on their own."

Theme 2: Informal education

The informal education theme comprises the codes "hidden curriculum" and "informal education." We assigned these codes to data that identified opportunities for teaching and learning that were ancillary to the activities of the spaces or were not connected to formal educational institutions or outputs. Within informal education, three subthemes emerged: collaborative learning (comprised of skills sharing and mentorship), environment, and exploration/failure.

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Collaborative learning: Skills sharing

"There is a lot of interest in people passing their skills to other people" reported Jesse, the manager of a makerspace at an Irish university. "If someone is really passionate about a topic they can come in and give a lecture to other students." This willingness to share and teach skills is a key feature of collaborative learning in the spaces and was reported universally.

"When we get new members or if visiting artists come in they usually bring in with them a different way of looking at things or doing things, and the other members are always keen to learn from them," stated Charlie, the manager of a makerspace that specialises in print making, adding that if a skill is new enough or in demand enough, it may even result in an official workshop.

Skills sharing often comes about organically. Drew, the manager of another print making space, stated that:

> Most print makers will say they have learnt most from other print makers while in the studio . . .being around other people who have different skill sets and engaging with them and sometimes actually trading skills.

This is a sentiment echoed by Pat, the manager of a makerspace that caters mostly to middle aged and elderly men. He reported that the transfer of a skill often begins with the words "there's a much better way of doing that and I'll show you."

Most participants expressed an intrinsic interest in acquiring skills that will better enable them to engage in their hobbies or further their own careers. Alex, the manager of an art-focused makerspace, observed that when young artists in his makerspace are given the opportunity to acquire knowledge that is of high interest to them, they do not merely learn new skills and ideas, they "enthusiastically absorb them."

Collaborative Learning: Mentorship

Mentorship plays a significant role within makerspaces, as experienced individuals have the opportunity to guide and support those with less experience. In terms of learning, participants reported that mentors "offer technical expertise" (Charlie), "help develop skills" (Jesse), "provide insights" (Charlie), "troubleshoot challenges" (Jesse), and offer "valuable advice and encouragement" (Jude). In addition to technical skills, mentorship within makerspaces can also extend to practical knowledge about professional fields. For example, artists may receive guidance on networking, the importance of engaging with an international community, and how to identify and create opportunities (Alex). In short, they learn how to "be" not just "do."

"The generosity of the more established artists is always astounding," stated Alex, the manager of a makerspace for artists. Recent graduates share the space with established artists who often offer "little nuggets of advice" (Alex) as they work alongside each other. Learning can take place in a group or be from peer to peer and may be as informal as a conversation "over a cup of tea," added Charlie, the manager of an artists' space.

This is not limited to learning behaviours that may lead to success in a specific field; it also applies to behaviours that impact how an individual exists and adapts to society. Pat, the manager of a makerspace for middle aged and elderly men, related that for one of his members, Omar (not his real name), a Syrian international protection applicant living in Ireland, the makerspace he belonged to provided a sense of belonging and purpose. Denied the opportunity for employment because of his refugee status, the makerspace made him feel at home. Good with his hands and "cracking up because he was unable to work" the makerspace gave him the opportunity to utilise his skills and

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collaborate on projects. "If you want a job done, start it and he'll take over because he just wants to be doing things," stated Pat. The manager added that he had observed that Omar improved his English, developed friendships, and learned to engage with the wider Irish community. That engagement, that purpose, the feeling of usefulness, Pat concluded, has had a decidedly positive impact on Omar's mental health.

Environment

"The biggest barrier to getting something useful out of these spaces is the ability to design something that [a maker] might want," stated Kris, the manager of an entrepreneurial incubator. But what do makers want? "It's not about the money, or the equipment, it's more about the culture that we want around these spaces," stated Sam, the manager of a university fab lab.

The environment of a makerspace is crucial in fostering creativity, innovation, and learning, serving as a platform for unlimited exploration. Access to a diverse range of tools, equipment, and materials encourages participants to experiment and embrace a hands-on approach to knowledge acquisition. Most importantly, the participants suggested that "it's the people that make the place," with makers thriving in an inclusive, supportive space where there is a sense of belonging within the community.

Both Sam and Jude described the makerspace as "a melting pot" where skills and experience are shared, which, continued Jude, made it "a positive experience for everybody."

Shea, the manager of an artists' makerspace, further stated that the absence of a formal hierarchy for validation or interpretation of work allowed for unbridled expression, as participants embrace the freedom to generate project ideas themselves and form a network of peers.

Key attitudes within this environment include "passion" (Sam), "enthusiasm" (Jesse), "fun" (Jesse), a sense of agency in shaping their creative journey, and "a feeling of ownership of the space" (Jesse). In addition, participants demonstrate "commitment to their projects" (Jude), a "shared interest," a "willingness to discuss their work" (Jude), and an air of "openness and approachability" (Charlie).

"Being part of a group, being connected to a network is so important because it's very difficult to work especially in the creative field by yourself," stated Charlie, the manager of an arts-focused makerspace. Kris, the manager of the entrepreneurial incubator, concurred. "It's a different thing to be creating by yourself in a studio and coming into a communal workspace where there are shared values and shared aims and goals and having that support then as well. It's a different thing. It's a much more dynamic space." He concluded that "Going into a space is [getting] into a mind-set." He outlined the artist's thinking as:

> I'm going into this space and it's a creative space. That's where I make work and that's where I will meet other creative people and it's where new ideas sometimes start. I think it's very important. It's greater than the sum of its parts.

Exploration/Failure

"How do you get people to come and feel like they feel welcome and feel like they want to use a space and feel like they can make a mistake without being branded as stupid or incompetent or whatnot?" stated Kris. He added:

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> It's very important to get that thing right within a place like this because they are intimidating. Makerspaces are intimidating. No matter what you do, you are asking people to come in and use something in public that they have never used before and with all of the opportunities for mistakes and grinding gears and loud noises and whatnot, it makes people blush and go red. So, it's about making sure that you can make a mistake and if you break something it's o.k. We'll fix it and we understand that nobody does these things on purpose and it is more of a learning culture to the place whereby you feel like you can experiment, debate and learn and ask questions.

Many people, communities, and institutions recognise makerspaces as safe havens for participants to embark on journeys of exploration and experimentation. Individuals are encouraged to step out of their comfort zones, try new things, and, if the experiment or project is not successful, embrace the valuable lessons that arise from failure (Alex). What matters is that "inquiry is deep" (Shea) and participants learn how to "fail better" (Shea), two attributes that may fuel personal growth. "If we were able to do everything perfectly the first time, there will be no learning and no sense of achievement," stated Kris.

Similarly, Alex, the manager of an artists' makerspace, stated that the elimination of the fear of failure is key in empowering makerspace participants. Once eliminated, "everything becomes a possibility." He suggested that the first step may be to remove shyness or hesitancy to experiment due to personal lack of experience. Alex recounted:

> Young graduates come in and they're literally like rabbits in the headlight. They're so terrified; it's the fear of the blank canvas…They're given an empty space and we give them a small bursary for materials and they get whatever technical support they might need. My colleague works very closely with them to try and mentor and encourage them as much as possible. We've realised over the years that the quicker you get them actively working, embedded into the culture of the organisation and actually participating and not feeling hesitant because someone more experienced is doing something similar, the quicker you break that [fear] down, the more they get out of it.

The makerspace's supportive environment cultivates enthusiasm for discovery, troubleshooting, and the thrill of overcoming challenges when solving problems. This passion for experimentation can become contagious, spurring participants to immerse themselves further in the process. As learners engage in more experiments, they gain confidence in their abilities, empowering further exploration. Such self-assurance often results in participants requesting specific equipment or materials that cater to their unique projects (Jesse). Learning to use the new tools is often self-directed and can further enhance self confidence in exploration (Jesse).

In short, fearless creating, innovating, playing, and exploring can lead to further and more creating, innovating, playing and exploring, an infinite loop with limitless possibilities for learning and creation.

Theme 3: Future directions

"Something I would really love to see is a way to formally create pathways among organisations," stated Alex, the manager of an artists' makerspace. All participants expressed similar interest and support for greater collaboration among makerspaces, at the local, regional, and national levels. The envisioned network would enable members to use each other's facilities and equipment,

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coordinate knowledge sharing, and facilitate greater community awareness. Participants pointed out that such collaboration could facilitate national makerspace research and perhaps improve access to government funding as attained funds could be spread to a wider audience and help fuel more collaborative projects. Collaboration "ticks a lot more boxes" and makes makerspaces "more appealing to funding bodies," stated Kris.

In terms of learning in makerspaces, managers have noted a shift towards projects, processes, materials, and equipment that are more eco-friendly and sustainable (Jesse, Alex). With an eye to future affordability, Kris encourages makers and aspiring makers to be trained with free open-source software whenever tasks permit.

Inclusivity, community engagement, and greater membership diversity were also prominent values among all makerspaces. Managers from academic institutions (Jesse and Sam) were especially keen on the creation of a learning commons, where learners from different disciplines could apply their skills in a mutually shared space and learn and collaborate with each other. Artistic space managers expressed interest in mixing backgrounds, like science and art, as they could lead to new and unexpected opportunities for making and creating. Drew, the manager of an arts makerspace, provided opportunities for post-primary transition year students to use the space to make and explore; in so doing, he enabled them to learn and grow in a non-traditional academic manner.

An unexpected benefit of the COVID pandemic was that many maker organisations turned to providing online lectures for their members and the general public. Many of the institutions found that online attendance was higher than past attendance for similar face to face lectures. For Alex, not only did Zoom help him reach a larger audience, it also reduced anxiety to perform for those who may be exploring maker activities for the first time.

Lastly, Kris was committed to using his makerspace as a "creative incubator" or prototyping space to encourage members' entrepreneurial endeavours. Makerspaces, he argues, could help people from a variety of disciplines "find a pathway to building businesses for themselves based on their own creative ambitions."

DISCUSSION

The pedagogical value of makerspaces lies not solely in access to tools or technologies, but in the learning cultures they cultivate. By legitimising experimentation, collaboration, and productive failure, makerspaces support learning dispositions, such as resilience, curiosity, and self-efficacy. Higher education increasingly recognises these dispositions as critical graduate attributes within higher education, aligning makerspace practices with broader institutional goals for student learning and development.

Our interviews with makerspace managers reinforced the general benefits noted in the literature—that is, how makerspaces can foster opportunities for hands-on acquisition of skills such as problem-solving, critical thinking, collaboration, and communication (Kurti et al. 2014; Sheffield et al. 2017) and can serve as part of the infrastructure for developing skills for the future (Valente de Jesus Rosa, Martinho Guimaras Pires Pereira, and Ferretti 2018).

Furthermore, the learner traits described by the managers of various makerspaces who participated in the study align with the attributes that universities desire to imbue in their graduates. These include curiosity, an interest in lifelong learning, the acquisition of new skills, an openness to new ideas, agency over personal learning goals, and the ability to make things happen (National Forum for the Enhancement of Teaching and Learning in Higher Education 2019). Developing these attributes prepares students for uncertainty, complexity, and ongoing change in professional and

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civic life, particularly in contexts where graduates are expected to adapt, collaborate, and continue learning beyond formal education.

Perhaps one of the main questions to ask is: Could the same learning have been achieved without a makerspace? Alex noted that many of the discussions among artists for feedback happened "over a cup of tea." However, those discussions may not have happened, had not there first been a space for collaboration where artists could examine each other's work and build mutual trust and camaraderie. In this way, makerspaces function not only as sites of making, but as social and pedagogical environments that support relationship-building and a sense of belonging, which in turn underpin collaborative learning.

Furthermore, individual projects in those spaces have sparked ideas for others that they may not have otherwise conceived if they were working in isolation. Additionally, the mere existence of a space for learning can lead to the creation of workshops where members learn and offer to share and teach new skills, the learning equivalent of "build it and they will come."

For our discussion, we have considered three main ideas related to our initial research questions: 1) making for learning and teaching, 2) making for inclusion, and 3) making higher education and community building.

Making for learning and teaching

Findings from this study suggest that makerspaces may function as sites of pedagogical belonging, social connection and shared purpose mediate learning. A growing body of higher education research highlights the importance of belonging and community for student engagement, persistence, and wellbeing (Felten and Lambert 2020). The data presented here indicate that makerspaces may mitigate some of the isolating tendencies of traditional academic environments, because they foster relational learning, mentorship, and identity formation as learners and makers.

As both the literature and our data shows, makerspaces are emerging as transformative environments within higher education, offering a rich, diverse, and inclusive approach to teaching and learning (Reynaga-Peña, Myers, Manuel Fernández-Cárdenas, Cortés-Capetillo, Glasserman-Morales, and Paulos 2020). One key aspect of their impact is the incorporation of diverse types of assessment. In traditional educational settings, assessment often relies heavily on written work. Makerspaces, however, encourage students to demonstrate their understanding and skills through a wide range of methods, such as project portfolios, presentations, and hands-on demonstrations. This diversity in assessment mirrors many real-world scenarios where practical application of knowledge is highly valued. It ensures that learners from various backgrounds and with varying strengths can excel, creating a more inclusive educational environment.

Moreover, makerspaces offer abundant opportunities for peer learning. As stated previously, Jesse, the manager of a makerspace at an Irish university, observed the benefits first hand, He also believed there would be even greater positive impacts if this sharing could be "nurtured up a little bit more, particularly at the undergraduate level." The literature on this topic is unequivocal. Collaborative projects and problem-solving activities thrive in these settings, allowing students to share their knowledge and skills with one another (Soomro, Casakin, Nanjappan, and Georgiev 2023). This peer-to-peer interaction fosters a sense of community and inclusivity, as students from diverse backgrounds come together to learn and teach (Reynaga-Peña et al. 2020). Additionally, makerspaces provide a platform for applying theoretical knowledge in practical contexts. This application of theory can deepen understanding and prepare students for the challenges of their future careers. It builds self-confidence (Taheri et al. 2020) as students witness their ability to translate academic concepts into tangible outcomes. Furthermore, the process of experimentation, reflection, and learning from

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failure is deeply ingrained in makerspace culture. Students are encouraged to take risks, try new ideas, and iterate on their projects. This not only boosts their resilience and problem-solving skills but also nurtures a growth mindset, wherein failures are seen as opportunities for growth rather than setbacks (Soomro et al. 2023). In this way, makerspaces offer a more holistic and inclusive approach to education that enriches students' knowledge and equips them with essential life skills.

Making for agency, participation, and pedagogical inclusion

Makerspaces have the potential to reshape aspects of higher education pedagogy by foregrounding learner agency and participation. One of their most significant advantages is that they give learners agency over their own learning (Reynaga-Peña et al. 2020). In contrast to traditional classroom settings, where students often passively receive information, learners become active creators and problem solvers in makerspaces. "Nothing is out of bounds," stated Jesse, describing both content and process, a sentiment to which all managers agreed. Regardless of the type of space, learners are encouraged to explore their own interests and passions, leading to a deeper understanding of the subject matter. This agency fosters a sense of ownership and empowerment, making education a more meaningful and transformative experience for students (Reynaga-Peña et al. 2020). Whether they are designing 3D-printed prototypes, programming robots, or crafting artistic installations, our data suggests that students and broader community participants in makerspaces are active contributors to knowledge instead of passive consumers of it.

In this study, inclusion is understood primarily in pedagogical terms, referring to the creation of learning environments that support multiple modes of participation, diverse interests, and learner-led pathways, rather than demographic representation alone. Furthermore, makerspaces function as learning commons where individuals from a variety of disciplines can come together (Cooke et al. 2018). This interdisciplinary nature of makerspaces encourages collaboration and knowledge exchange among students and teachers from diverse backgrounds. It facilitates cross-disciplinary experimentation, allowing students to explore connections between seemingly unrelated fields. For instance, a computer science student may collaborate with an arts student to create an interactive installation, merging technology and creative expression. This cross-pollination of ideas leads to innovative solutions and a more holistic approach to problem-solving, in turn preparing students for the complex challenges they will face in the real world. Our data also points to how makerspaces promote a dynamic and participatory learning environment that transcends traditional disciplinary boundaries and fosters a culture of creativity and innovation in higher education.

Making, higher education, and community building

There is little in the literature specifically about creating a network of makerspaces. However, insights can be extracted from the existing scholarship, which are bolstered by the interviews. These perceived benefits extend beyond practical considerations such as funding, access to expertise, or visibility. In higher education research, community, connection, and a sense of belonging are widely recognised as central to student engagement, persistence, and success. Felten and Lambert (2020) argue that learning environments that intentionally foster meaningful relationships—among students, educators, and wider communities—create the conditions for deeper learning and student wellbeing. Viewed through this lens, networks that connect higher education makerspaces with community-based spaces can be understood not only as resource-sharing initiatives, but as relationship-rich learning environments that extend opportunities for connection beyond institutional boundaries. From a pedagogical and community perspective, aligning makerspaces in higher education with those in the wider community could present numerous synergistic benefits.

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Firstly, it could lead to more funding opportunities as collaborations between educational institutions and local communities often attract more resources and support from both public and private sectors (Cooke et al. 2018). Additionally, it could offer better access to skilled practitioners from various backgrounds, enriching the educational experience for students with real-world expertise (ibid). This alignment could also improve advertising to communities, fostering increased participation and engagement. Furthermore, it could expose communities to a diverse range of hobbies and practices, promoting inclusivity and cultural exchange. Such collaborations could serve as the foundation for the formation of a "Living Lab," where innovative ideas are tested in real-world contexts, benefiting both students and the community (Della Santa, Tagliazucchi, and Marchi 2022). Moreover, it could enhance the digital footprint of these makerspaces, making them easier to discover online and thereby expanding their reach and impact. In essence, aligning makerspaces in higher education with those in the wider community could create a mutually beneficial ecosystem that amplifies the benefits and potential of these creative and collaborative spaces. "In short," Kris stated, "I think it's just an important way to think about making spaces and rather than [them] being in competition, if [they're] in partnership, it's a much better way to go."

LIMITATIONS

Although the present research provides a rich insight into the opportunities for teaching and learning in makerspaces, it explores these opportunities exclusively from the perspective of the managers and directors of these spaces. Additionally, the sample includes participants from a number of different types of makerspace, but the majority were from spaces with a focus on the creation of art, and within an Irish-only context. Due to the diverse nature of makerspaces, the homogeneity of the participants should be considered a limitation of the study. We also acknowledge the small data set for this particular study, and therefore make the following recommendations for future research in this area.

FUTURE RESEARCH

Several potential areas could benefit from further exploration. Research is needed that includes participants from all aspects of the maker community, e.g. managers and directors, members of the spaces, users from the community, and collaborators. Future research should also include a diverse range of spaces, including spaces self-identifying as makerspaces, hackerspaces, fab labs, art studios, fabrication spaces, and other community organisations with a focus on creating.

Additionally, future research could examine the impact of participation in makerspaces on mental health more closely. Benefits to mental health is not an attribute tracked in Kraus, Bouncken, Görmar, González-Serrano, and Calabuig (2022) on the state of makerspace research in academia. Nonetheless, we propose that it is of great relevance. Research on the impact on participation in Men's Sheds has on men's physical and mental health (Kelly, Steiner, Mason, and Teasdale 2021; McGrath, Murphy, Egan, Ormond, and Richardson 2022) reported positive results and could be replicated at the tertiary level. The Irish Health Service Executive's Pathways to Wellbeing National Mental Health Promotion Plan (2024 – 2030) advocates various measures to assist in the promotion of good mental health at all levels of education, including a "whole college approach" that includes curricular based and extra-curricular based approaches (Department of Health 2024), of which the engagement in makerspace activities could be included.

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CONCLUSION

The findings presented in this study, drawn from interviews with makerspace managers in Ireland, underscore the multifaceted benefits of makerspaces for fostering teaching and learning opportunities. Makerspaces provide avenues for both formal and informal education, catering to a diverse range of learning styles and needs. The collaborative and inclusive environment within these spaces encourages individuals to share their skills, mentor one another, and engage in peer learning, thereby fostering a strong sense of community. Moreover, makerspaces provide a safe and supportive environment for experimentation and learning from failure; they nurture essential traits such as creativity, curiosity, a lifelong pursuit of knowledge, and agency over personal learning goals. As such, this study highlights the transformative potential of makerspaces in shaping a more inclusive, engaging, and innovative educational landscape.

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DISCLOSURE

None.

ETHICS

The University College Cork ethics committee granted ethics approval for this study in 2020.

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