Using Makerspaces to enrich Design and Technology education

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The studies of Vourikari et al. (2019) and Walan & Gericke (2022), show that a significant amount of research on makerspaces focuses on how these community spaces provide an informal approach to learning that promotes cross-curricular Science, Technology, Engineering, Art, Mathematics (STEAM) education without considering how this could enrich design and technology education. Limited exploratory research has been conducted in the Maltese context on how makerspaces can enhance the professional development of design and technology teachers, supporting students' transition into the workforce, particularly in design, engineering, and technology-related occupations. By conducting an exploratory case study at a makerspace located in the Valletta Design Cluster (VDC) in Valletta, Malta, using observations and interviews as key methods, this study aims to understand the culture of makerspaces, the knowledge and skills exchanged by users, and how these align with engineering and technology literacy requirements (ITEEA, 2020). It also examines the teaching strategies employed, with particular focus on student-centred approaches. Four key themes emerged from the observations and interviews conducted at the makerspace: "teaching and learning methods," "opportunities within makerspaces," "knowledge and skills," and "makerspace users." These themes not only provided a deeper understanding of Malta's makerspace culture, but also highlight the educational potential of makerspaces. This study concludes with a suggestive interpretive account by the researcher, based on the results and literature findings, detailing how makerspaces could enhance formal design and technology education in Malta.

Keywords: design and technology, makerspaces, education, opportunities, teaching and learning.

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Introduction:

In Malta, Design and Technology (D&T) is an elective multidisciplinary subject in Maltese secondary schools where students focus on modelling their ideas and building artifacts or projects that solve given or identified problems using an iterative design process. According to the 2026 D&T syllabus published by the MATSEC examination board which is referred to as the "SEC33 D&T 2026 syllabus", D&T instils students with the necessary key skills, knowledge, and attitudes leading to STEM (science, technology, engineering and mathematics) careers, or more specifically, careers related to design, engineering and technology (DET) (The James Dyson Foundation, 2018; MATSEC Examinations Board, 2023; ITEEA, 2020).

If one were to closely examine the SEC33 D&T 2026 syllabus, to evaluate whether it aligns with recent engineering and technology literacy standards, such as those published in the "Standards for

Technological and Engineering Literacy" (STEL) document in 2020 by the International Technology and Engineering Educators Association (ITEEA), one would see that students may not be thoroughly evaluated on their conceptual and metacognitive knowledge. One would also find that they are also not thoroughly assessed on their ability to collaborate effectively and maintain a positive attitude towards improving their work (ITEEA, 2020).

This is concerning because collaboration forms part of the eight technology and engineering practices (i.e. a set of behaviours aligned with technology and engineering activity), found as core in the STEL 2020 document. Collaboration is considered to be one of the highly sought for 21st century skills (Walan & Brink, 2023). These are skills which are essential to aid individuals in being adaptable in today's ever-changing world (Koul, Sheffield, & McIlvenny, 2021).

In light of these disparities, it could be proposed that the utilisation of makerspaces could aid in addressing the collaborative skill and knowledge gap in D&T education. This is because makerspaces are reported to promote the collaborations amongst teachers and students with external stakeholders, that is makers and manufacturers (Tabarés & Boni, 2021). Most projects worked on in makerspaces are community based, therefore individuals working in makerspaces would be employing higher order thinking skills, such as critical thinking and creativity, in solving real-world problems identified in different communities (Walan & Brink, 2023). This makes makerspaces promoters of the highly sought for 21st century skills (e.g. a) collaboration, b) creativity, c) problem solving, d) social skills and e) communication) (Walan & Brink, 2023).

Seeing this potential, the question of "how can makerspaces enrich design and technology education" naturally comes to mind. In this study, this broad research question is further divided into three sub-questions, listed in Table 1, to capture the educational opportunities that makerspaces could offer D&T education. In this study, each research question is addressed after data collection from a case study conducted in one of Malta's makerspaces.

Table 1.

Sub-research questions addressed in this study.

Research questions	Aim of research question
RQ1: How can a makerspace be used by D&T teachers?	To suggest various ways how a D&T teacher could utilise a makerspace for professional development or to cultivate in students the highly sought-after skills utilised in the DET sectors.
RQ2: Could the teaching and learning of D&T be enhanced by involving teachers and students in collaborative community makerspace activities?	To explore how collaborations with individuals working in DET sectors and participation in maker activities could enrich the teaching and learning of D&T in formal secondary education settings
RQ3: Should makerspaces be integrated into formal education?	To explore the different methods and mindsets utilised in makerspaces that could be integrated into formal education to promote the utilisation of more student-centric teaching and learning methods.

Literature review

Brief introduction to makerspaces

A makerspace is a shared facility or workshop where individuals embrace the do-it-yourself culture. This includes hobbyists, engineers, artists, crafters, and educators (Browder, Aldrich, & Bradley, 2019; Holm, 2015). In makerspaces, these individuals come together to create physical goods (either for personal use or mass production) or contribute to community projects (Browder, Aldrich, & Bradley, 2019; Holm, 2015). The advent of makerspaces has also introduced a new mindset known as the "maker mindset," which shapes the outlook of individuals who find intrinsic fulfilment in creating physical or digital objects. This maker mindset encompasses resilience, creativity, a growth mindset, a willingness to tinker, and a collaborative orientation (Cohen, Margulieaux, Renken, Jones, & Smith, 2018).

A successful makerspace is one in which users embrace these cognitive constructs, as a makerspace is defined by the processes of making and the application of the maker mindset. Otherwise, the concept of a makerspace may fail, functioning instead as a mere service provider of tools and workspace for those who lack access to such facilities.

Description of a typical makerspace

In a makerspace, one may expect to find a diverse array of traditional tools for metalwork, woodworking, arts and crafts, similar to those found in a secondary school D&T lab, a number of advanced subtractive and additive manufacturing machines (i.e. CNC milling machines, laser cutters, and 3D printers), programming tools, micro-controllers, and even biotechnology equipment (Holm, 2015; Browder, Aldrich, & Bradley, 2019). The spaces in a makerspace are co-located to aid individuals to foster a sense of community and collaboration, encouraging individuals to share their work, engage in conversations, and participate in co-design activities (Aldrich, 2019). This collaborative atmosphere is further facilitated by communal access to tools and resources (Browder, Aldrich, & Bradley, 2019).

Educational opportunities of a makerspace

Although not designed as learning institutions, makerspaces and the maker education they foster (a type of engineering education rooted in the DIY (Do-It-Yourself) culture of the maker movement), have attracted educators' attention (Vourikari et al., 2019).

Makerspace activities are based on Papert's theory of constructionism and may involve entirely tech-based projects or a lot of crafting or tinkering (Jones, 2023; Gonzalo Aller Arias & González González, 2018). This approach encourages organisers of these activities to use less structured, more informal teaching methods and assessments (Vourikari et al., 2019).

In formal learning institutions, assessment is usually summative (Vourikari et al. 2019). However, during makerspace activities, learning is formative in nature, as the activities are performative, process-driven, and intrinsic (personalised and based on the participant's interests) (Walan & Gericke, 2022).

Makerspaces foster collaboration between individuals from diverse fields. This makes makerspace activities interdisciplinary (Koul, Sheffield, & McIlvenny, 2021). As stated before, this enhances students' motivation by exposing them to real-world economic and social issues (Tabarés & Boni, 2021). Hence, giving students a sense of purpose in their participation. In addressing these issues, students develop persistence, resilience, and problem-solving skills, embodying the maker mindset (Fasso & Knight, 2020). Thus, makerspaces support the European Key Competences for Lifelong Learning (e.g., literacy, digital competence, entrepreneurship, analytical thinking) and 21st-century skills (Education and Training, 2019; Walan & Brink).

Since activities in a makerspace are often interdisciplinary, makerspaces can be considered promoters of STEM education (Vourikari, Ferrari, & Punie, 2019). In maker education, subjects are not siloed as they are in formal secondary school education. This is because to create a physical artifact, collaboration among people from various fields is required naturally (Koul, Sheffield, & McIlvenny, 2021; Tabarés & Boni, 2021).

In makerspaces, teaching and learning are more student-centric, as these spaces often operate for extended hours, giving users ample time to experiment and reflect on their mistakes (Vourikari et al., 2019). This creates a learning environment where failure is accepted and viewed as a learning opportunity, in contrast to a system that assesses students' learning through summative exams (Walan & Brink, 2023). This creates an environment where autodidactic learning is possible, as students can self-educate themselves through experimentation at their own pace without worrying about deadlines (Blikstein, 2021).

Learning in a makerspace can be goal-directed (intentional) or unplanned (incidental), with the latter often arising through experimentation or problem-solving (Vourikari et al., 2019). A drawback of incidental learning is its irregularity, as it may not ensure that students meet all syllabus learning outcomes (Tabarés & Boni, 2021).

Learning in a makerspace is flexible, ranging from peer learning and mentoring to structured workshops (Vourikari et al., 2019). Unlike formal education, makerspaces allow participants of all ages to engage in project-based, multidisciplinary learning in an informal setting (Walls et al., 2023; Tabarés & Boni, 2021). They can collaborate as peers or groups, sharing knowledge and designing freely, within themes, or building on concepts initiated at school (Gonzalo Aller Arias & González González, 2018; Laru et al., 2019).

Since makerspaces emphasize European Key Competences for Lifelong Learning and student-centered teaching, Gonzalo Aller Arias & González González (2018) suggest adapting school spaces like libraries, workshops, and computer labs into makerspaces to foster collaboration, creativity, and openness (Gonzalo Aller Arias & González González, 2018). This transformation includes adding flexible furniture, diverse tools, and materials for arts, crafts, engineering, and technology projects (Gonzalo Aller Arias & González González, 2018).

Methodology and methods

Information about the VDC makerspaces.

To answer the research questions stated in Table 1 a case study methodology was conducted in Malta's Valletta Design Cluster's (VDC) makerspace. This was chosen as there was no other makerspace in Malta that was in alignment with Holm's (2015) typical makerspace descriptions. Housed within the VDC building, this fully equipped makerspace caters to various disciplines, offering tools for metalworking, woodworking, textiles, electronics, casting, moulding, computer-aided design, CNC milling, cutting, routing, 3D printing, and embroidery (Valletta Design Cluster, 2022). Accessible to students (over 18), residents, researchers, creative start-ups, and cultural/creative enterprises, the makerspace provides a designated workspace and expert guidance for prototyping ideas, particularly for those lacking essential equipment or technical skills (Valletta Design Cluster, 2022).

Case study methodology

The exploratory case study method was chosen to explore the educational benefits of makerspaces for both D&T teachers and students. The chosen methodology was deemed suitable for constructing an in-depth understanding of the VDC's makerspace. The case study's utilisation of various data collection methods and participants aided to comprehensively depict the makerspace's functions, users, activities, and the development of maker culture in Malta. The collected results where then triangulated to enhance data reliability and present an unbiased and realistic portrayal as much as possible (Cohen, Manion, & Morrison, 2018).

Methods

The case study methodology involved semi-structured interviews and non-participant observations conducted in parallel. The semi-structured interviews were chosen to be conducted with the head of the VDC and the makerspace users. This method allowed participants to provide more in-depth subjective opinions, reflections, and interpretations on how they use the makerspace and how it could be utilised for educational purposes (Cohen, Manion, & Morrison, 2018). The interview with the VDC's head aimed to understand the makerspace concept, including its primary users and purposes, and to explore how a D&T teacher might use it to enhance D&T education from the VDC head's perspective.

The interviews with regular users of the VDC makerspace were aimed to understand the reasons behind these individuals' usage and motivations. These were also done to gather suggestions on how the makerspace can transform into an ideal environment where designers and makers could collaborate with D&T teachers to compliment D&T learning and facilitate the practice of skills outlined in the ITEEA's STEL 2020 document, which may not receive adequate emphasis or assessment in the SEC 33 D&T 2026 syllabus. The participants were selected through purposive sampling, focusing on individuals with backgrounds in design, engineering, and technology. These participants were required to possess sufficient subjective data, including experiences, feelings, impressions, and opinions, to contribute valuable insights on how potential changes could be made to the makerspace to make it an ideal space for collaboration with D&T teachers.

The Interview data was triangulated with systematic, non-participant observations of VDC members in the makerspace. To conduct these observations, the researcher prepared observation schedules with predetermined elements taken from previously read literature to observe. This approach was aimed at validating interview findings and providing a comprehensive description of the maker culture, capturing the context, routines, and activities within the VDC Makerspace (Billups F. D., 2021). The observation schedules were designed to also capture any emerging subjective themes and critical incidents not part of the makerspace's routine, allowing the researcher to note new insights during observations (Given, 2008).

To analyse the data collected from the three data sets (the interviews with the head and makerspace users and the systematic non-participant observations), the researcher utilised the thematic analysis inductive coding method. An inductive approach was chosen for coding the data to prevent bias from claims made by other researchers about makerspaces being agents of change in D&T education at the secondary school level (Braun & Clarke, 2006). Therefore, coding was done inductively, avoiding pre-existing codes or analytic preconceptions (Braun & Clarke, 2006).

This method was also chosen due to its flexibility and potency to be used with more than one type of data set. The audio collected data in the interviews and observations was converted into non-verbatim text. Then this was utilised to arrange the data into themes that represent patterns of meaning. The grouped data was then presented in a thematic map, for the reader to be able to see how the data analysis was developed, identified into main themes, subthemes, and how they are logically interconnected (Braun & Clarke, 2012).

The researcher did not invite any D&T teachers or students to participate. The main reason was that the researcher aimed to observe a makerspace in its natural state, to understand its day-to-day functions and how people learn in an informal environment without specific set learning outcomes. The results will be presented as a set of proposals on how D&T teachers could benefit from the use of makerspaces, based on the interpretations of the researcher, who is herself a D&T teacher.

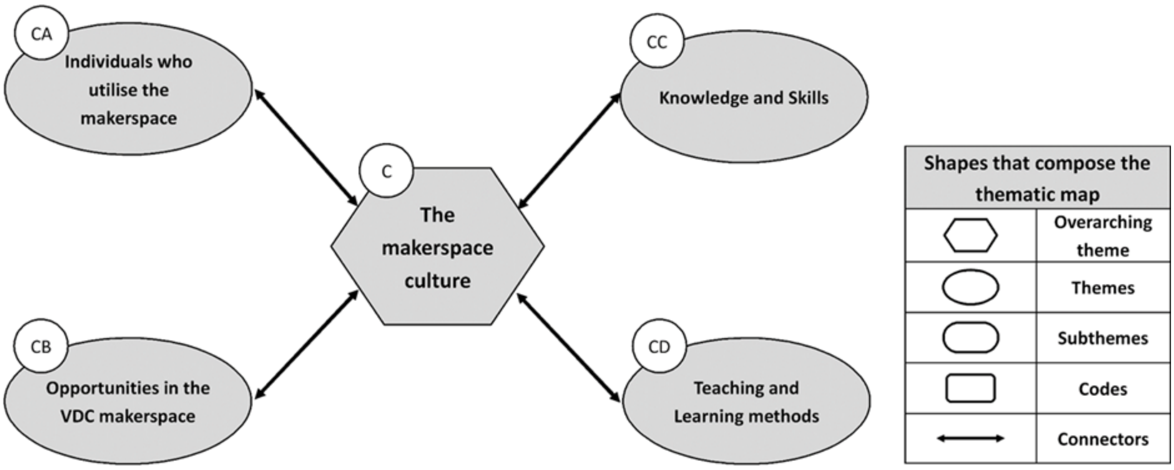
Results

The formation of a thematic map

During the data collection period, a total of 8 observations and 8 interviews were conducted, with one interview being with the VDC head and the remaining seven with makerspace users. These were done to study the makerspace culture by understanding the lived experiences of regular users of the makerspace. In doing so, the researcher was able to identify elements that distinguish a makerspace from formal learning institutions and explore how such elements could enrich the teaching of D&T. The data collected through interviews provided insights regarding the VDC makerspace from the perspective of the makerspace users, while the information gathered through observations reflected the researcher's interpretations. Using the NVivo software, the information from both data sets was coded and grouped into themes following the guidelines provided by Braun and Clarke (2006), resulting in the formation of a simplified thematic map with four main themes relating to the makerspace culture, as depicted in Figure 1.

Figure 1.

Thematic map of the main overarching theme C: The makerspace culture

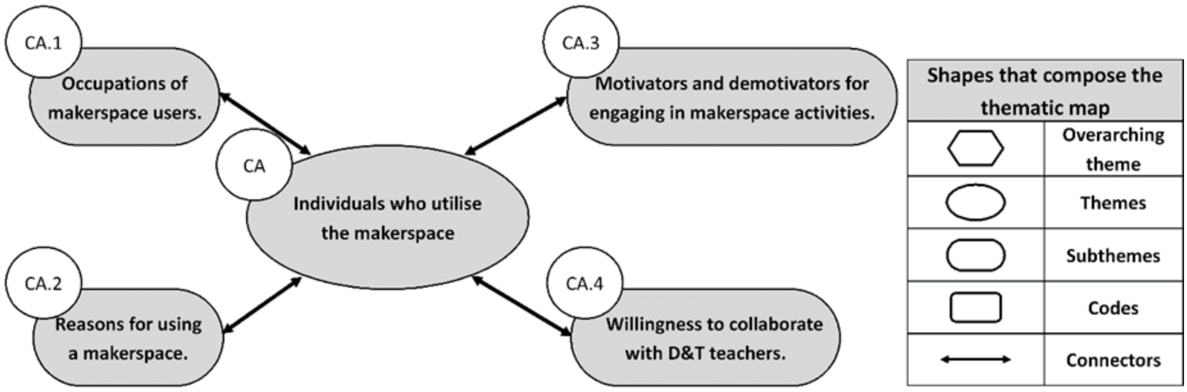


Individuals who utilise a makerspace

The first theme labelled CA (see Figure 2), was created to explore the types of individuals who use a makerspace and their reasons for doing so. This allowed the researcher to form suggestions regarding how these individuals could collaborate with D&T teachers to enhance the teaching and learning of D&T.

Figure 2.

Thematic map of theme CA: Individuals who utilise the makerspace



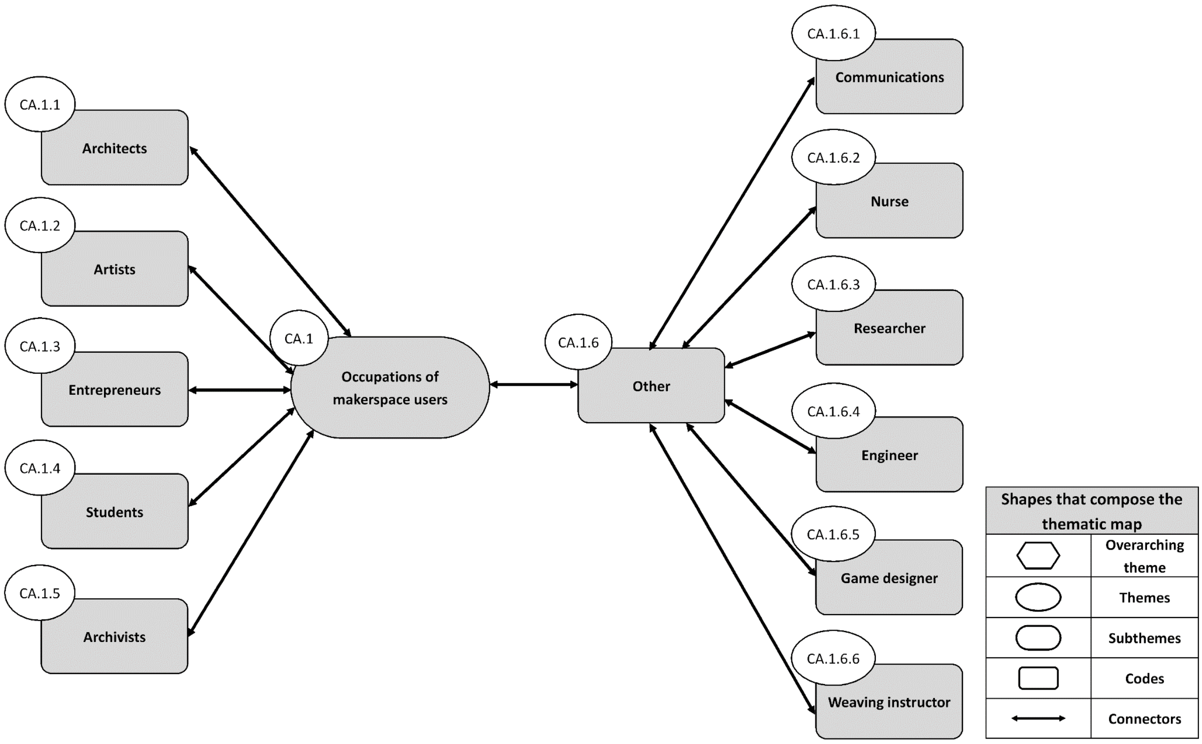
Subtheme labelled CA.1 (see Figure 3) reveals a diverse mix of individuals using the VDC makerspace, including architects, artists, entrepreneurs, students (enrolled in art and design courses), and archivists.

While seemingly individuals from creative and cultural backgrounds are predominant users, the "CA.1.6: Other" (see Figure 3) category indicates participation from other non-artistic and cultural backgrounds. This suggests that makerspaces are inclusive environments where participants could participate in a wide range of projects. This opposes the statement made by Leonard et al. (2022) that makerspaces are exclusive environments for those with pre-existing knowledge.

As shown in subtheme labelled CA.2 (see Figure 4) the participants' main reasons for utilising a makerspace were either to collaborate with someone, to conduct workshops, to have access to a space with tools and machines, to participate in interesting activities and to learn or improve skills and knowledge.

Figure 3.

Thematic map of subtheme CA.1: Occupations of makerspace users



As seen in code labelled CA.2.1 (see Figure 4) most of the participants utilised the makerspace because it provided them with the opportunity to connect and work with other like-minded individuals to explore various projects and approach tasks from diverse perspectives. This supports the statement made by Browder et al. (2019), of makerspaces being environments where participants engage in collaborative efforts with other like-minded individuals. During interviews, it was noted that being in a makerspace facilitates idea exchange, this was termed as “cross-pollination of ideas”. This aligns with the findings of Vourikari et al. (2019), where they emphasise that learning in a makerspace is mostly incidental. This is again supported by Hui and Gerber (2017), who suggest that members observing each other's tasks boosts confidence in conducting similar activities.

As seen in code labelled CA.2.2, (see Figure 4) participants who used the makerspace to conduct workshops aimed to share their skills, introduce people to new crafts or processes and build a sustainability-focused community, highlighting the educational role of makerspaces. This supports the concept that learning in a makerspace could also be goal-oriented (Vourikari, Ferrari, & Punie, 2019).

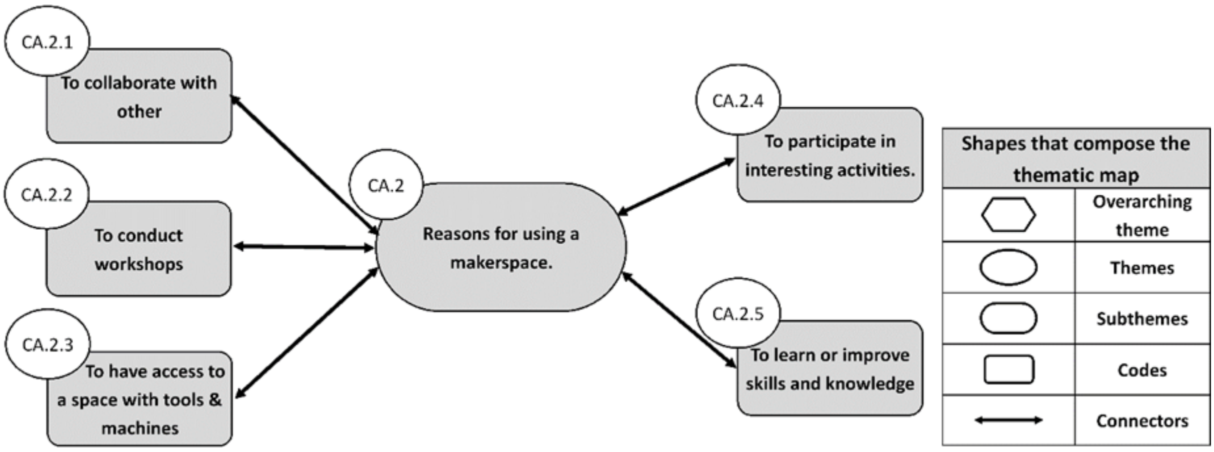
As seen in code labelled CA.2.3 (see Figure 4) participants also found the resources in the makerspace valuable for collaborative experiments and personal research, especially for those working in studios with limited equipment. Also, the availability of advanced equipment motivated some individuals to pursue innovative projects beyond their current capabilities.

Participants using the makerspace to participate in interesting activities, as seen in code labelled CA.2.4 (see Figure 4), stated that they would engage in the activities only if the activities were relevant to their skills, knowledge, and professional or hobbyist background (see Figure 4). To spark interest in new multidisciplinary endeavours and foster collaboration across domains, activities must involve individuals with varied skills coming from different disciplines.

Participants that engaged in makerspace activities to acquire new skills or enhance existing knowledge (see code CA.2.5 in Figure 4) aimed to expand their skill set for future projects and explore unfamiliar processes, demonstrating a proactive approach to personal growth within their craft.

Figure 4.

Thematic map of subtheme CA.2: Reasons for using a makerspace



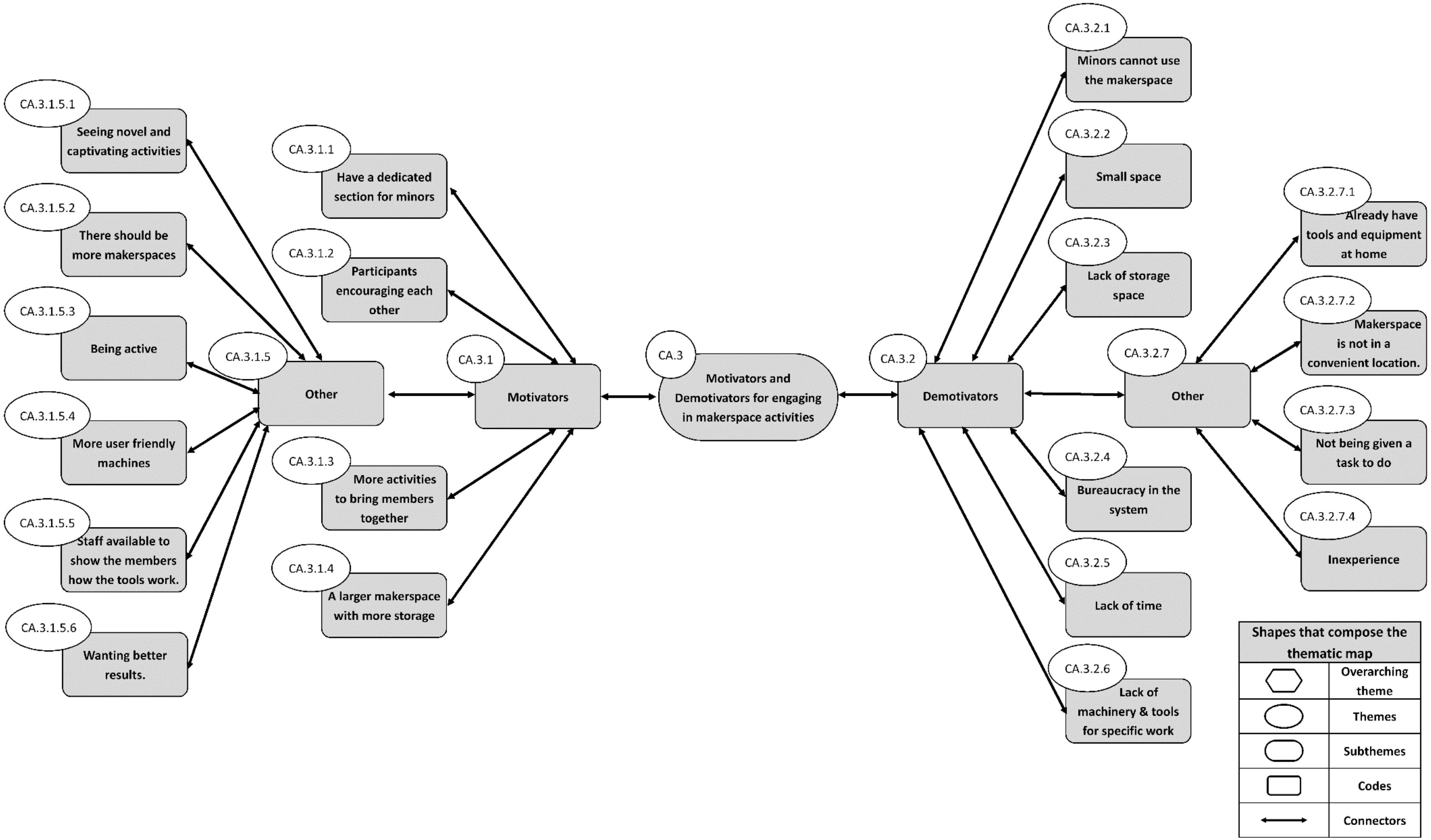
The subtheme labelled CA.3 (see Figure 5) shows the various factors that affect the participation of the participants in makerspace activities. Participants highlighted the makerspace's age restriction, which posed challenges for those working with minors professionally (see code CA.3.2). They proposed the establishment of makerspaces tailored for minors as they could offer educational opportunities beyond basic crafting workshops. Such spaces could foster collaboration between teachers and students, enriching learning beyond the classroom. Additionally, participants emphasised the significance of education outside of school hours, suggesting that makerspaces could nurture skills essential for future employment not covered in formal education.

Lack of task assignments and inexperience (see codes CA.3.2.7.3 and CA.3.2.7.4) were significant demotivators for makerspace participants. They relied on a leader figure within the group for encouragement and task assignments during activities. Without this motivation, they tended to remain inactive. This reliance on a leader was more prominent among inexperienced participants due to their limited project management experience, resulting in a continuous need for step-by-step guidance. The last four demotivators, as depicted in Figure 5, were bureaucracies in the system for booking an available space, lack of time for participants to engage in makerspace activities, individuals who already possess tools and equipment at home or work, and the makerspace being in an inconvenient location (see codes CA.3.2.4-CA.3.2.7.2).

The identified key motivators for participants (see code CA.3.1 in Figure 5) to take part in makerspace activities were activities that brought makerspace users together, seeing novel and captivating activities and the availability of more makerspaces. These factors strengthened the sense of community and facilitated the identification of potential collaborators. Additionally, the layout of the makerspace, with rooms divided by glass doors at the VDC, allowed participants to observe parallel activities, promoting incidental learning (Vourikari, Ferrari, & Punie, 2019). Several participants also agreed that there should be more makerspaces for accessibility reasons and additional tools to conduct a wider range of activities and meet their project needs more effectively. Internal motivating factors identified included being active and striving for better results. Observations indicated that an individual's sustained engagement in an activity was influenced by their personal characteristics and abilities (i.e. whenever participants had nothing to do, they would go to assist other groups).

Figure 5.

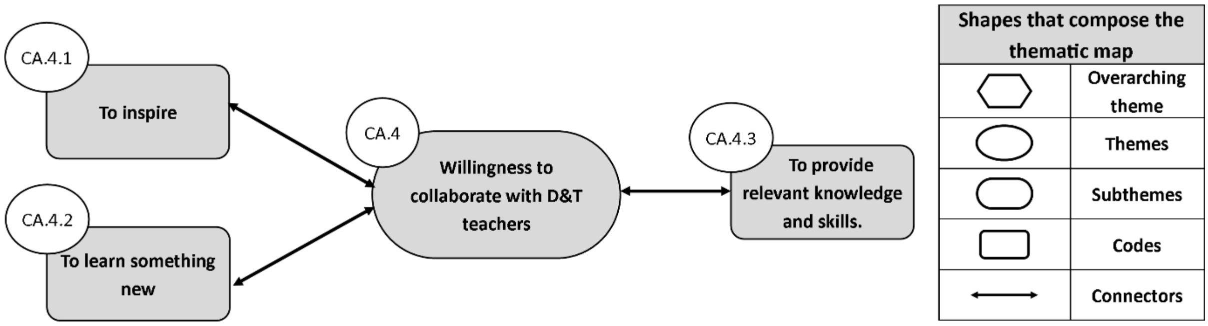
Thematic map of subtheme CA.3: Motivators and demotivators for engaging in makerspace activities



In the subtheme labelled CA.4 (see Figure 6), participants expressed their readiness to partner with D&T teachers to inspire students and showcase the practical applications of the D&T subject (see code C.4.1). They were willing to introduce students to potential career paths, post-secondary schooling and sustain their interest in the D&T subject by highlighting real-world relevance (see code CA.4.3). While many were eager to engage in collaborative projects with D&T teachers to expand their knowledge and problem-solving skills, their participation depended on the project's alignment with their individual skills and interests (see code CA.4.2).

Figure 6.

Thematic map of subtheme CA.4: Willingness to collaborate with D&T teachers



Opportunities in the VDC makerspace

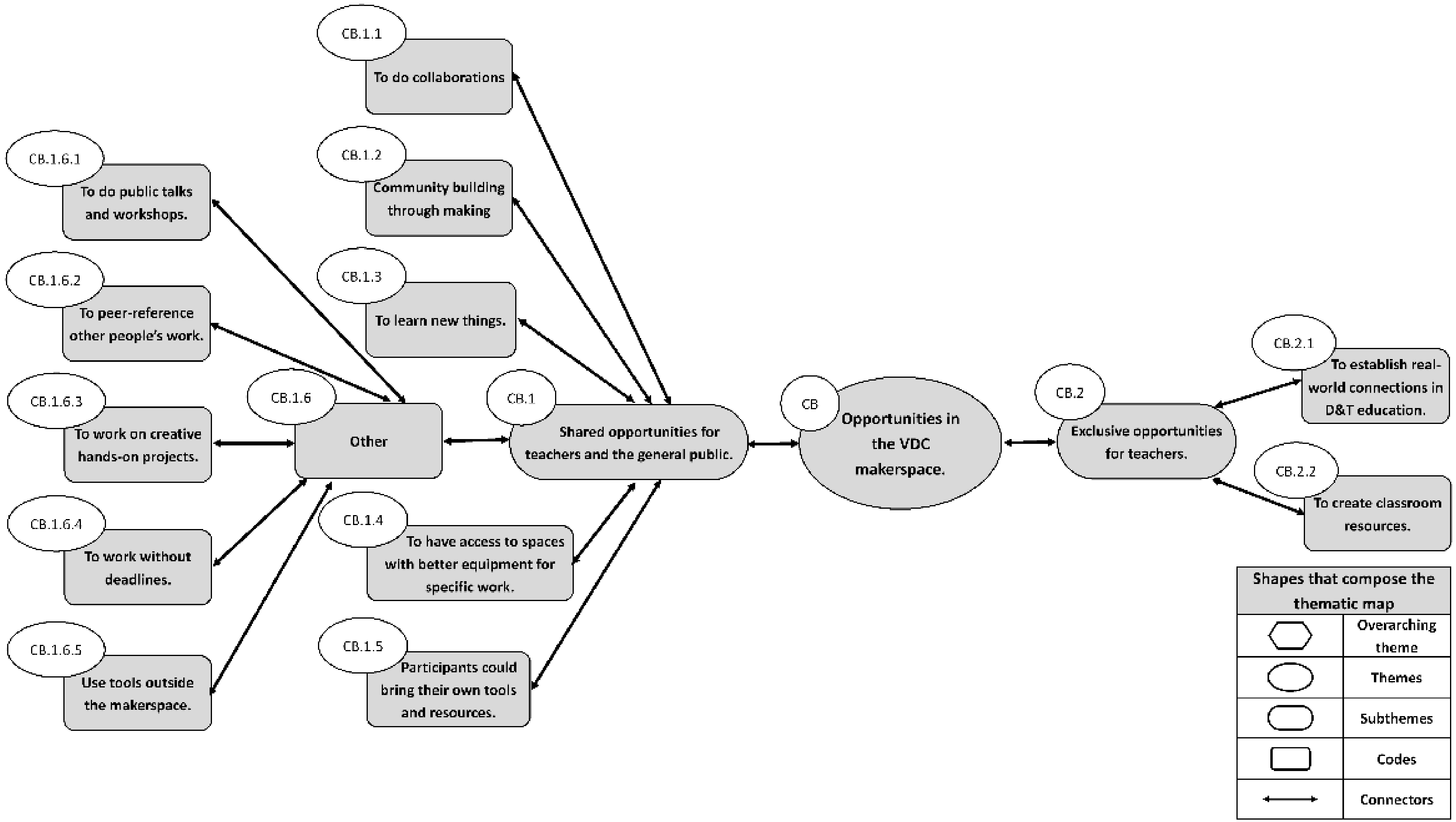
Theme "CB: Opportunities in the VDC makerspace" (see Figure 7) highlights various possibilities for teachers and students within a makerspace, based on the participant's suggestions and observed activities. As shown in code CB.1.1 teachers in a makerspace could collaborate with individuals outside their profession, fostering mutual learning and skill acquisition, this is facilitated by the makerspace's layout with glass doors allowing peer observation and inspiration (see code CB.1.3).

When participants shared knowledge by teaching each other machine operations, this demonstrated the makerspace's potential for individuals to experiment and conduct prolonged creative projects with advanced equipment (see code CB.1.4 in Figure 7). While workshops and talks by teachers were proposed, minors are not allowed to be present in the makerspace due to the presence of potentially dangerous machinery (see code CB.1.6.5 in Figure 7). Despite this, teachers and students could bring their tools for diverse activities elsewhere (see code CB.1.6.5 in Figure 7). Additionally, teachers could create intergenerational making communities, informing students and families about D&T and career prospects, aligning with Aldrich's (2019) notion of democratising entrepreneurship through makerspaces; however here it could be seen that makerspaces have the potential to democratise D&T education for all ages.

The last set of proposed opportunities for teachers is that they could utilise the makerspace for the creation of classroom resources (see code CB.2.2 in Figure 7). Participants were also willing to assist teachers in understanding D&T's possibilities beyond compulsory education and integrating modern CNC machinery into their teachings (see code CB.2.2 in Figure 7). This potential collaboration could foster tangible connections within D&T education, enriching teaching practices and providing educators and their students with insights into real-world design applications within industries (see code CB.2.1 in Figure 7)

Figure 7.

Thematic map of theme CB: Opportunities in the VDC makerspace



Knowledge and Skills in the makerspace

With the coded data, theme "CC. Knowledge and Skills" was collated and as could be seen in Figure 8, it depicts the commonly used skills (see code CC.1 in Figure 8) and knowledge (see code CC.2 in Figure 8) in the makerspace. This aided to determine whether in a makerspace, students under 16 years of age (if they were allowed in a makerspace) would learn skills and knowledge not emphasised in the current SEC33 D&T 2026 syllabus at schools.

In the makerspace, as shown in subtheme labelled "CC.1: Skills applied at the makerspace," technical skills were the most prominently applied, followed by creative thinking, problem-solving, collaboration and teamwork, leadership, critical thinking, and graphic design (see codes CC.1.1-CC.1.7 in Figure 8).

Observations revealed consistent use of technical skills during makerspace activities, integral to tasks involving tools and material creation.

Collaboration and teamwork were pivotal, with participants working in teams to address project aspects, requiring creative, problem-solving, and critical thinking skills.

Leadership skills were crucial, especially during observed activities that involved the construction of large art installations. In these situations, effective team management and communication were key to project success.

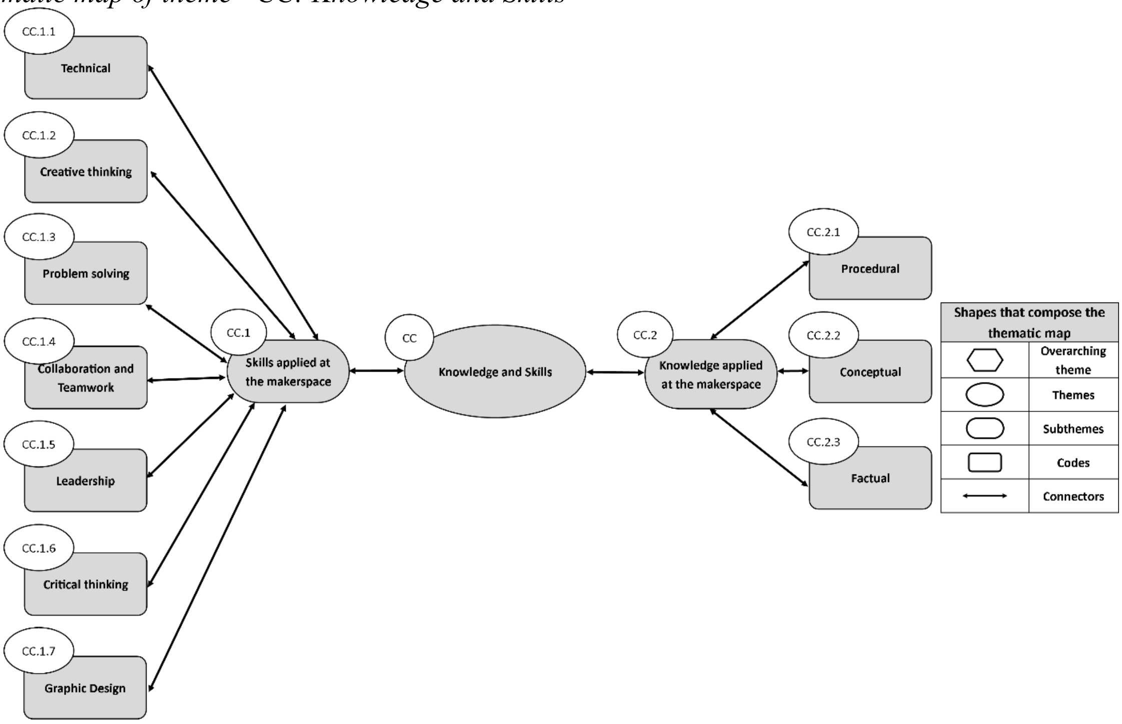
Graphic design skills were prominent during activities where the participants had to visualise concepts for an artistic street installation project. This highlighted the importance of versatility in both digital and physical mediums for design purposes.

In subtheme code labelled "CC.2: Knowledge applied at the makerspace" (see Figure 8), participants utilised procedural, conceptual, and factual knowledge during makerspace tasks. Procedural knowledge was prominently shared as participants sought to understand work processes and machinery. During a street installation activity, diverse participants collaborated, exchanging knowledge on tool use to achieve success. This knowledge exchange was also evident in workshops where participants that were organisers of activities explained to participants how to use specific equipment in the makerspace.

Conceptual (see code CC.2.2 in Figure 8) knowledge emerged as participants shared experiences from past projects, to inspire and learn from one another. Factual knowledge (see code CC.2.3 in Figure 8) was highlighted in workshops, where details about processes (i.e. participants explaining certain laser cutting specifics with diode laser cutters) were shared.

Figure 8.

Thematic map of theme "CC: Knowledge and Skills"



Teaching and learning methods employed at the makerspace.

Participants employed various teaching and learning methods during community projects and workshops in the makerspace, aiming either to instruct formally or informally aid others in completing tasks. As depicted in theme labelled “CD: Teaching and Learning methods” (see Figure 9), the pedagogical methods were categorised into teacher-centric and student-centric approaches to explore whether the makerspace employs pedagogies different from traditional teacher-centric methods in formal education.

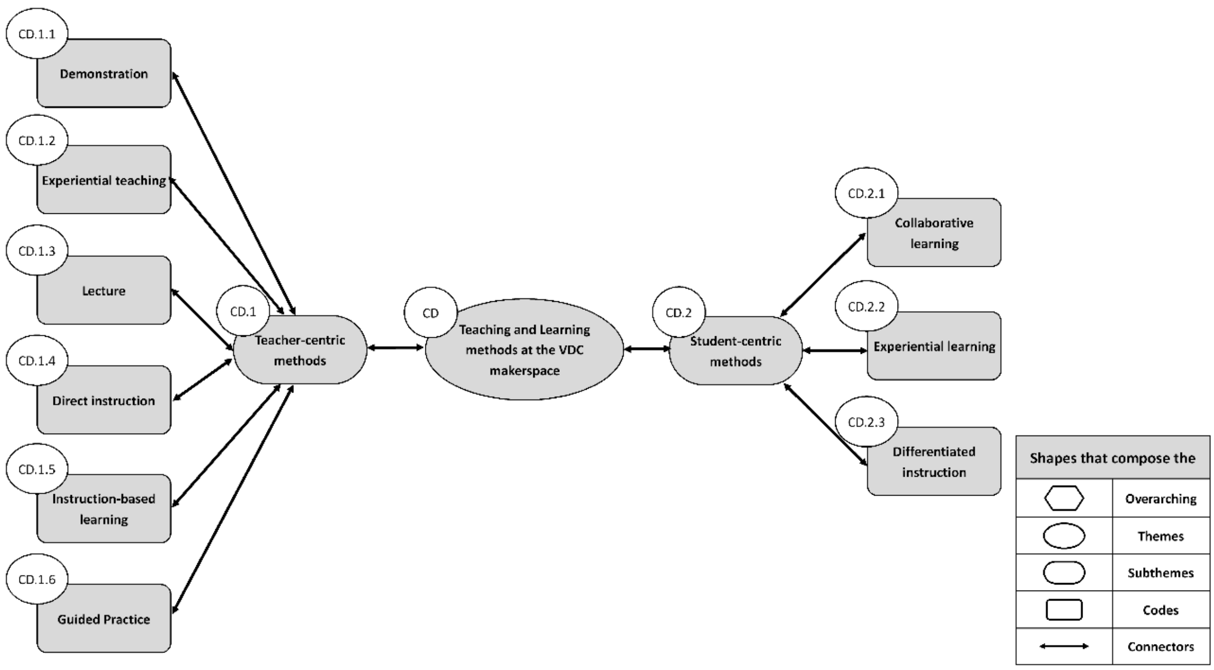
Figure 9 illustrates a prominent use of traditional teacher-centric methods over student-centric ones, aligning with Sang & Simpsons' (2019) critique of makerspaces favouring guided approaches, potentially constraining student autonomy. However, the choice between traditional and modern teaching methods varied based on activity nature (i.e. whether someone is instructing someone or working in a team with an equal role) and participants' experience levels.

It is notable that teachings in the makerspace did not solely rely on factual knowledge but also on experiences. The utilisation of experiential teaching (see code CD.1.2 in figure 9), aimed to inspire participants, facilitate their work and avoid unnecessary pitfalls experienced in prior projects.

Regarding student-centric teaching and learning methods, collaborative learning, experiential learning, and differentiated instruction were utilised (see Figure 9 for codes CD.2.1-CD.2.3). These methods were predominantly employed during autonomous team-based activities without frequent guidance from a leader figure and during workshop segments where participants worked independently, with a leader figure available to assist with individual needs.

Figure 9.

Thematic map of theme “CD: Teaching and Learning methods at the VDC makerspace”



Discussion

How can a makerspace be used by D&T teachers?

From the collated data, a makerspace is more than just a provider of space and tools for collaborative or individual production (Browder, Aldrich, & Bradley, 2019). It also serves as a centre for informal learning. This was evident from the number of individuals participating in makerspace activities with the intent to learn or teach. Further evidence of this was observed during collaborative work, where incidental learning occurred as each person contributed unique skills and knowledge. Therefore, it could be suggested that makerspaces are ideal environments for D&T teachers' professional development and (if a makerspace were available for students under 18) a place to practice more informal, student-centric teaching and learning methods with their students.

From the results and referenced literature, it can be inferred that if a D&T teacher were to utilise a makerspace (or implement makerspace practices), they would be able to:

- Relate teachings to Real-World Applications: Makerspaces provide opportunities for students to engage in tasks that mirror real-world scenarios, fostering critical thinking, creativity, and collaboration. This aligns with UNESCO's mandate emphasising the need for graduates capable of agile thinking and problem-solving, essential for today's rapidly changing world (Koul, Sheffield, & McIlvenny, 2021). Collaboration, a key competence for lifelong learning recognized by the EU, thrives in makerspaces, preparing students for future workforce challenges (Koul, Sheffield, & McIlvenny, 2021; Education and Training, 2019).
- Utilise Diverse Teaching Methods: The use of teaching methods in makerspaces varies depending on the activity. Student-centric methods were prevalent during team-based tasks, and they facilitated the practice of higher-order thinking skills. Working in teams promotes incidental learning, enhancing students' problem-solving abilities and creativity.
- Learn from experiences: Makerspaces provide a platform for experimentation and learning from experiences. Unlike traditional school settings with limited lesson times, makerspaces offer extended operating hours, allowing students and teachers to experiment, refine ideas, and engage in self-evaluation and iteration. This cultivates a growth mindset, emphasizing continuous improvement and intrinsic motivation.
- Cross-Pollinate Ideas: Makerspaces allow participants to learn from activities happening concurrently in other rooms. This phenomenon enables individuals to be inspired or gain insights from diverse projects and activities. Teachers engaging in makerspace activities could contribute to a broader knowledge-sharing network. For example, D&T teachers could inspire others in the field while enhancing their own skills and knowledge. However, the success of this network depends on how aligned the organized activities are with the participants' interests, knowledge, skills or hobbyist background, ensuring sustained inspiration and motivation. This supports Dougherty Dale's (2015) assertion that makerspace participants are primarily driven by intrinsic goals rather than external rewards.

Could the teaching and learning of D&T be enhanced by involving teachers and students in collaborative community makerspace activities?

The results show that individuals in makerspaces practice technical, creative, problem-solving, collaboration and teamwork, leadership, critical thinking, and graphic design skills. Comparing these skills with those assessed in the SEC33 D&T 2026 syllabus reveals overlap, indicating that many makerspace skills are already evaluated in schools. However, makerspaces offer additional opportunities for students to collaboratively engage in creative and innovative projects.

Makerspaces offer individuals the chance to apply higher order thinking skills, particularly in large community projects involving diverse backgrounds such as science, design, and art. This mirrors the collaborative nature of work in DET sectors, where expertise from various fields is crucial for functioning products. The research suggests that makerspaces provide real-world contexts, preparing students for DET careers.

However, the results collated from the thematic analyses suggest that adaptability might not be extensively practiced in makerspaces. Limited prior knowledge of participants' backgrounds made it challenging to identify this skill. Yet, all participants, regardless of background, navigated the unfamiliar makerspace environment, seeking advice on tools. This suggests that makerspaces offer informal settings for students to adapt and expand their knowledge.

Regarding types of knowledge practiced, makerspaces focus on procedural, conceptual, and factual knowledge, aligning with the activities and skills involved in producing physical objects. However, the application of metacognitive knowledge in makerspaces was less clear. The researcher found it challenging to identify this form of knowledge due to limited awareness of participants' pre-existing knowledge. If a reflective account had been collected from each participant after each makerspace activity, indicating what they learned and how they developed professionally in skills and knowledge, it might have been easier to identify instances of metacognitive knowledge. This limitation is a noted weakness of this research.

Should makerspaces be integrated into formal education?

As per collated results in the thematic analyses, makerspaces offer valuable educational opportunities for teaching D&T in a cross-curricular and collaborative manner, fostering experimentation and formative assessments. Increasing accessible makerspaces in Malta, even for minors, would broaden their educational reach, given that many individuals already use them for educational purposes and incidental learning. However, due to safety concerns, makerspaces are primarily designed for adults, prompting the suggestion of integrating makerspace concepts into schools (Gonzalo Aller Arias & González González, 2018). Schools could adapt existing spaces like libraries or D&T workshops to function as makerspaces, with government support for additional equipment if needed (Holms, 2015; Blikstein, 2021). Yet, constant supervision by technical staff would be necessary for student safety.

To ensure practical use, designated time slots for teachers and students to utilise makerspace benefits could be implemented, possibly during weekdays or holidays. Alternatively, integrating the maker mindset approach into D&T education could be beneficial, focusing on constructs like resilience, growth mindset, creativity, willingness to tinker, and collaboration (Dougherty, 2015). This approach encourages project-based learning assessments, promoting students' transversal skills in practice (Becker & Lock, 2021). However, while this integration offers educational benefits, it may not fully utilise the collaborative potential of makerspaces (Cohen, Margulieaux, Renken, Jones, & Smith, 2018). Collaborative work in teams allows for knowledge sharing and interdisciplinary approaches, ensuring D&T's relevance in students' every day and work lives (Cohen, Margulieaux, Renken, Jones, & Smith, 2018).

Conclusion

This case study offers a comprehensive understanding of makerspaces, drawn from literature, interviews, and observations, utilising a thematic analysis approach. The main themes derived, "Individuals who utilise the makerspace," "Opportunities in the VDC makerspace," "Knowledge and Skills," and "Teaching and Learning Methods," reveal that makerspaces can transform D&T education in secondary schools. They employ student-centric teaching methods, fostering incidental learning and collaboration in community-based projects, reflecting real-world practices. This facilitates the assessment of higher order thinking skills like creative thinking, critical thinking, problem-solving, communication, collaboration, leadership, and adaptability. Makerspaces also allow students to experiment and learn without the constraints of deadlines imposed in formal education, offering valuable experiences for both D&T teachers and students, potentially enhancing interest in the subject.

Identified weaknesses in the research.

While this research highlights the transformative potential of makerspaces in D&T education, several limitations warrant consideration. The study did not explore how makerspaces could directly aid secondary school D&T teachers' professional development through student-centric teaching methods, as no teacher participants were involved. Due to the methodology chosen, conducting experiments with teachers in the makerspace was not feasible. However, similar studies, such as Walan and Gericke (2022), have shown that integrating makerspace activities into lessons can enhance student motivation, collaboration, and creativity.

Furthermore, the research's validity and reliability were influenced by the single researcher's involvement, potentially limiting data aspects and interpretations. Involving multiple researchers could have offered diverse perspectives and minimized biases (Braun & Clarke, 2012). The study's sample size and observed activities were also limited due to the makerspace's newness and limited equipment at the time of data collection. This suggests that the VDC's makerspace might not have been widely known, impacting its usage.

Lastly, the data was derived from observations and interviews conducted in a single location, implying that the findings should not be generalized to all makerspaces. Instead, they serve as suggestive insights into how makerspaces could potentially benefit D&T teachers and students in their professional and academic development.

Suggestions for future research

Makerspaces are relatively underutilised in Malta's educational institutions compared to other countries (Gonzalo Aller Arias & González González, 2018), limiting evidence-based research on their educational benefits locally. However, this study lays a foundation for future investigations into makerspaces' role in Maltese D&T education.

The study suggests that makerspaces offer educational opportunities for D&T teachers and students to enhance their professional and academic development. The next step would involve engaging a group of D&T teachers to explore makerspace practices and interactions with professionals in the DET sectors. Their feedback will be crucial in understanding how it assists them in developing professionally in terms of skills and knowledge. This will assist in assessing the feasibility of integrating these makerspace practices into formal education.

Subsequently, a qualitative study similar to Walan & Gericke (2022) could be conducted, implementing makerspace practices with students and comparing their performance to those in schools without such methods. This comparative analysis would provide insights into student skill development, motivation, and overall performance in D&T education, especially in areas typically not assessed in the SEC33 D&T syllabus. Such a study would be instrumental in determining the effectiveness of integrating makerspace practices into D&T education.

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