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Research Paper

Exploring teachers' understanding of collaborative learning and teamwork strategies in Design and Skills-Labs

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ABSTRACT

Makerspaces are interactive learning environments that provide students with opportunities to improve life and career skills. The importance of these spaces has grown over the years. In Türkiye, the Ministry of National Education has established makerspace-like environments, known as Design and Skills-Labs (Tasarım Beceri Atölyeleri or TBA in Turkish) in public schools. This study was conducted to explore public-school teachers' understanding of collaborative learning (CL) and teamwork strategies in the design and skills labs. The sequential exploratory design was applied for this mixed method research to collect data in two phases: qualitative interviews with experts working on makerspaces, followed by quantitative survey data collection from public school teachers who work in TBAs. The qualitative data were collected through semi-structured interviews from 13 national and international field experts to understand what collaboration and teamwork mean in makerspaces. The themes and subthemes that emerged from this phase guided the quantitative data collection phase. The latter was conducted in the form of an online survey with 101 public school TBA teachers. The results indicated that teachers know the importance of CL, its application, and strategies in the learning environment. However, CL strategies, assessment techniques, and resources continued to be one of the major challenges faced by teachers in TBAs. The factors that interfere with teachers' competencies include the lack of prior training on TBA environments. As for resources, financial and funding factors were speculated to be challenging as well.

INTRODUCTION

A makerspace is a collaborative and hands-on learning environment where individuals come together to create, experiment, and innovate using various tools and materials. The maker movement began as community-based groups that were interested in developing digital designs, manufacturing tools, and technology prototypes (Barrett et al., 2015). Many industrial businesses used the community-based concept to encourage creativity, provide opportunities in product development, and exchange resources (Barrett et al., 2015). This rapid growth in community-based groups that make, create, exchange, and produce would become one of the responsible components of the community-based makerspaces' concept (Moorefield-Lang, 2015). Originating from the do-it-yourself (DIY) movement, the makerspace model expanded to target today's education of science, technology, engineering, and mathematics (STEM) (Taheri et al., 2020). The implementation of these spaces became an important contribution to the learning processes and students' real-life skills development (Kajamaa & Kumpulainen, 2020). They have been established inside an institution as part of the curriculum (formal setting), or as an extracurricular activity inside a club, a lab, or other informal settings. Makerspaces provide students with a learning experience that benefits from digital and non-digital resources (Pocock, 2016). They encourage the use of imagination, creativity (Pocock, 2016), and provide students with opportunities to develop many skills including designing, prototyping, and testing as well as social and communication skills (Kajamaa & Kumpulainen, 2020). Makerspaces promote the educational-progressive goals that could not be achieved in traditional classroom practices (Taheri et al., 2020).

In Türkiye, the Maker Movement began following the visit of Dougherty, the leading advocate for the Maker Movement, in 2016 for a meeting with individuals and organizations (Erbay, 2017). After this visit, the first maker fair was held in Türkiye, the "Turkcell Technology Summit" (Makers Türkiye, 2016). This event attracted over 5000 visitors to view over 100 exhibited projects and promoted different events and organizations to raise awareness on the expansion of makerspace environments. Changes were constantly made to improve the needs in educational programs. Ministry of National Education, *referred to as MEB (Milli Eğitim Bakanlığı in Turkish) in this paper*, undertook a revision for the educational programs and the "2023 Education Vision" policy was published to achieve 44 objectives in varied educational themes (Misirli, 2019), including data driven decision-making, digital content, and others (MEB, 2020). Moreover, MEB's educational vision aimed to establish makerspace environments in all the K-12 public schools. Those makerspaces-like environments are named as "Tasarım-Beceri Atölyeleri" (Design and Skill-Labs in English), abbreviated as TBAs in this paper.

The current study was conducted in Türkiye, aiming to lead a shift towards innovative educational methodologies and environments (Gündoğan & Can, 2020). Recognizing the importance of nurturing social and career skills, Türkiye's MEB has diligently worked on establishing makerspaces (TBAs) in all the public schools. TBA initiative represents a forward-looking approach to preparing students for an evolving world, offering them the opportunity to connect their classroom knowledge with real-life applications and creative projects (Güleş & Kılınç, 2020). Initiated as part of the 2023 educational vision in Türkiye, these labs aimed to equip students with crucial skills, including problem-solving, collaborative teamwork, critical and creative thinking, interdisciplinary competencies, and the ability to transform knowledge into practical designs through a "process-based approach" (MEB, 2020) (See Figure 1).

Figure 1. MEB's (2020) Design and Skills-lab

MEB (2020) has reported that 9,137 TBA facilities have opened their doors to students across Türkiye, encompassing a wide range of activities, including drama, art, technology education, coding, robotics, and three-dimensional design (MEB, 2020). These labs have been implemented in public schools at all levels, spanning from primary schools to middle schools and high schools (MEB, 2020).

Background

Past studies have revealed the critical importance of designing project-based learning environments and preparing collaborative projects and activities to enhance students' learning outcomes in makerspaces (Le et al., 2018). Collaboration and teamwork have been found to boost students' critical thinking, motivation, and overall enthusiasm for learning (Rasmussen & Damsa, 2017; Nakata et al., 2020) and to provide students with opportunities for a community-based experience in learning (Bevan et al., 2014). According to Smith (2017), engaging within the community is important to foster a sense of belonging, empowerment, and trust among team members. Such an environment delivers a chance for students to decide on their designs in terms of "What" and "How" (Leskinen et al., 2021). Students, therefore, become focused and determined on their roles to come up with joint artifacts (Leskinen et al., 2021). Collaborative learning supports students' co-construction of knowledge, understanding, and development of new ways of thinking (Bullock & Sator, 2015).

Prior research has underscored the challenges associated with implementing collaborative learning, especially when it comes to organizing and assessing collaborative projects and activities within makerspaces (Le et al., 2018). These difficulties have often been attributed to teachers' limited proficiency in comprehending the structures and organization of collaborative learning, which can significantly influence the learning environment (Le et al., 2018). Despite the considerable interest in makerspaces and their potential for innovation in Türkiye, there has been limited academic research that specifically examines teachers and their abilities to facilitate learning within TBAs. Demirata and Sadik (2023) explored teachers' necessary competencies and competency-based needs in TBAs and highlighted the importance of project-based learning and designing collaboration and teamwork opportunities for students. Considering the importance of collaboration and teamwork in makerspaces and understanding teachers' competencies and needs, the present study focuses on TBAs as the specific context of interest and aims to investigate public school teachers' comprehension of the applications and strategies related to collaborative learning and teamwork in makerspaces and similar settings.

Purpose and Significance

The interest in teachers' understanding of collaboration and teamwork primarily centers on the formal setting of TBAs. Both collaborative learning and teamwork promote group interactions and collaboration. However, collaborative learning emphasizes the experience in knowledge construction and skills development while peers interact with one another, whereas teamwork concentrates on achieving an objective(s) through team efforts (Reeves et al., 2017). Therefore, our study seeks to address the following research question: How do public-school teachers describe their understanding of student-collaboration and teamwork in the Design and Skills Labs? This study has practical implications for understanding and implementing effective collaboration and teamwork strategies. Findings could support teachers in creating successful collaboration and teamwork opportunities for students in TBAs. In addition, the study informs in the creation of student-centered assessment that teachers can use with collaborative learning projects. Furthermore, this study provides administrators with insights and recommendations for trainings, professional development, or workshop that may support teachers and, hence students' learning in TBA and other makerspaces. Finally, the research contributes to the literature for understanding practices of makerspaces and TBA environments in Turkiye, specifically related to collaborative learning practices and strategies, and supports the development of the necessary policies to determine competencies for teachers working in TBAs.

METHOD

Research Design

This study is a mixed methods research (MMR) that followed a sequential exploratory design, as data were collected in two phases: (1) qualitatively using semi-structured interviews and (2) quantitively using an online survey (Creswell & Creswell, 2023). This design was adapted to explore the differences and/or similarities among teachers' strategies of collaboration and teamwork in TBAs. The sequential exploratory design was considered for this research to determine the influences of a phenomenon among a specific population (Creswell & Creswell, 2023; Morse, 1991). In other words, this design prioritized the qualitative data and utilized the quantitative data in the findings to aid in the interpretation of the qualitative data (Creswell & Creswell, 2023).

Phase 1: Qualitative

The qualitative phase of this study aimed to explore experts' knowledges and experiences in the field of makerspaces. The semi-structured interviews were designed to elicit responses from the participants through open-ended questions (McIntosh & Morse, 2015). Interviews naturally provide quality data that includes perspectives, thoughts, and descriptions of a certain phenomenon experienced by an interviewee from a target population (Merriam & Tisdell, 2015). Therefore, this phase of the study followed a phenomenological approach design. Nevertheless, the following flowchart (See Figure 2) reveals the steps that were taken in this phase.

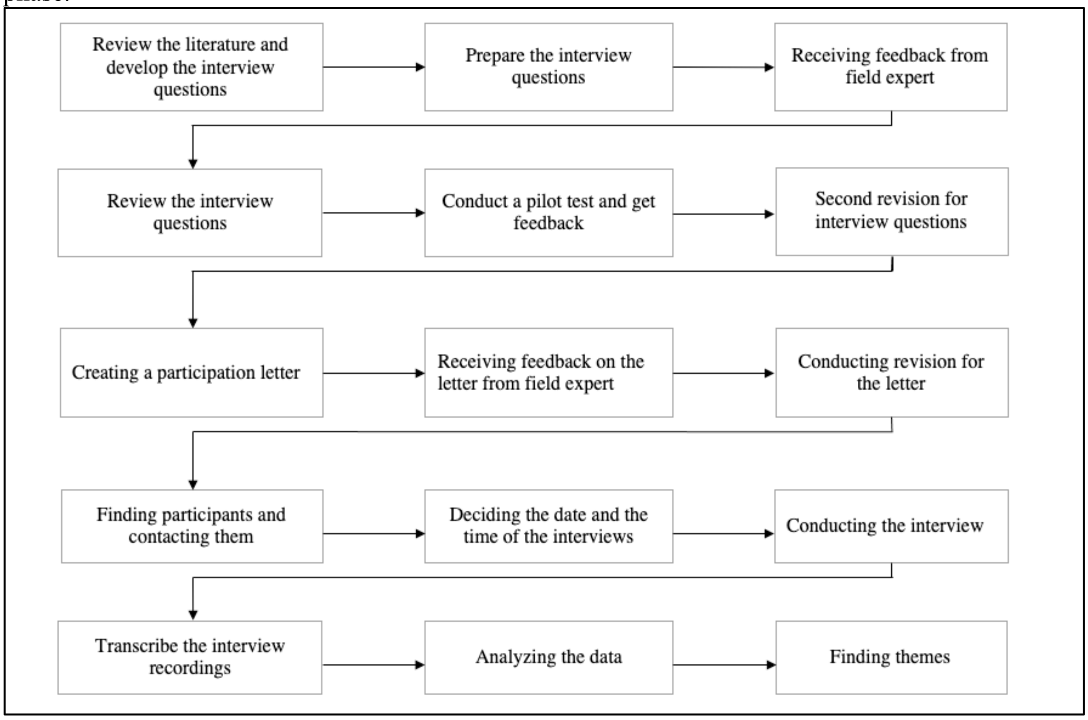

Figure 2. Flowchart for steps taken in phase 1

Participants. In this phase, a purposeful sampling technique (Creswell & Plano Clark, 2023) was used to recruit 13 participants from different parts of the world. This technique is used for the selection of individuals that have knowledge and/or experience with a certain phenomenon (Creswell & Plano Clark, 2017). The participants (See Table 1) were selected from experts with published journal research in makerspaces, and actively engaged in either K-12 or higher education contexts. This national and international participation was chosen to explore the similarities and differences of makerspaces around different parts of the world, and explored topics such as experiences, strategies, and challenges.

Table 1. *Interview participants in phase 1*

Participant	Gender	Country	Educational Background
1	Female	U.S.A.	PhD: Engineering Education
2	Female	U.K.	PhD: Geography
3	Female	U.S.A.	PhD: Engineering Education
4	Female	Germany	PhD: Learning Sciences
5	Male	Türkiye	PhD: Curriculum and Instruction
6	Male	U.S.A.	PhD: Educational Sciences
7	Male	U.S.A.	PhD: Entrepreneurship
8	Male	U.S.A.	PhD: Physics
9	Male	Türkiye	PhD: Literacy, Culture and Language Education
10	Female	Jordan	MA: Industrial Engineering
11	Female	Türkiye	In Process - PhD: Educational Technology
12	Female	U.S.A.	In Process – PhD: Information Science Studies
13	Male	Türkiye	MEd: Educational Technology

Prior to the interview, an invitation was crafted, providing an overview of the research and its aim, along with the interview duration (Appendix A). Interested participants confirmed via email and participated in the first phase.

Data Collection. Prior to conducting the interviews, the literature was reviewed to identify areas of focus for the semi-structured interviews. Based on this review, we created a set of interview questions that were presented to a field expert for feedback. Content revisions were made accordingly. Next, we conducted a pilot test with one subject-matter expert in makerspaces. The participant pointed out ideas and feedback while responding to the questions. The feedback was taken into consideration while making a second round of revisions to the questions (Appendix C). To recruit participants, the researchers created an invitation that included the topic and the aim of the study, along with a consent form. In total, we interviewed 13 participants who were academic scholars and field experts to understand what collaboration and teamwork means in makerspaces and the experts' definition of a successful collaboration and teamwork makerspace environment. The interviews lasted about 30 to 40 minutes for each of the interviewees. All participants consented to record the interviews via audio and/or video, and each interview was conducted online through the "Zoom" video conference application (Appendix B).

Data Analysis. Analyses began after all interview data were collected. The data were transcribed using the "verbatim" structure technique to maintain the data's integrity and preserve the exact wording of the interviews without any alterations (Halcomb & Davidson, 2006). Transcripts were imported to MAXQDA for coding using content and thematic analysis. The codes were reviewed to generate themes and subthemes. Eight main themes and thirty-eight subthemes originated from the analysis.

Validity and Reliability. To enhance the trustworthiness of the first phase of the study, detailed descriptions about the participants and procedures were included. The interview questions were developed from the literature and a subject-matter expert revision was included to improve the quality of the questions (Merriam & Merriam, 1998). Moreover, a pilot test with a subject-matter in the field was conducted to enhance the credibility and the reliability of the research (Creswell & Poth, 2016). The purposeful sampling technique was used to narrow down the target population and increase the quality of the study (Patton, 2014). Member checking was also applied to decrease any inaccuracy in the data and the findings. This was completed by contacting the participants to get their approval of the findings or asking more information on a certain response (Creswell & Poth, 2016).

Limitations. Despite careful and intentional planning, there were certain inevitable limitations. First, the pilot test in the first phase was conducted with only one subject-matter expert. Second, the qualitative data took about 4 months to complete due to busy schedules and time zone differences of both the participants and the researchers. Third, the interviews were carried out online as the participants are in other countries or different cities in Türkiye.

Phase 2: Quantitative

Participants. Participants were recruited by sharing the survey online (Appendix D) using social media and other online platforms (e.g., Instagram, Facebook, LinkedIn, and Telegram) to reach the target population (Van Selm & Jankowski, 2006). In this phase, participants were public-school teachers in different K-12 levels and cities around Türkiye where TBA were implemented. A total of 168 participants voluntarily undertook the survey online. However, only 101 responses were valid for analysis (67 did not have TBA at their school or did not agree to the terms of the study). Most participants (n = 71, 70.3%) identified as female (See Table 2).

Table 2. *TBA teachers participated in the survey.*

		Gender			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	71	70.3	70.3	70.3
	male	30	29.7	29.7	100.0
	Total	101	100.0	100.0	

The age ranged between 23 and 52 years old. Participants' teaching experience ranged from between 3 to 10 years (See Figure 3).

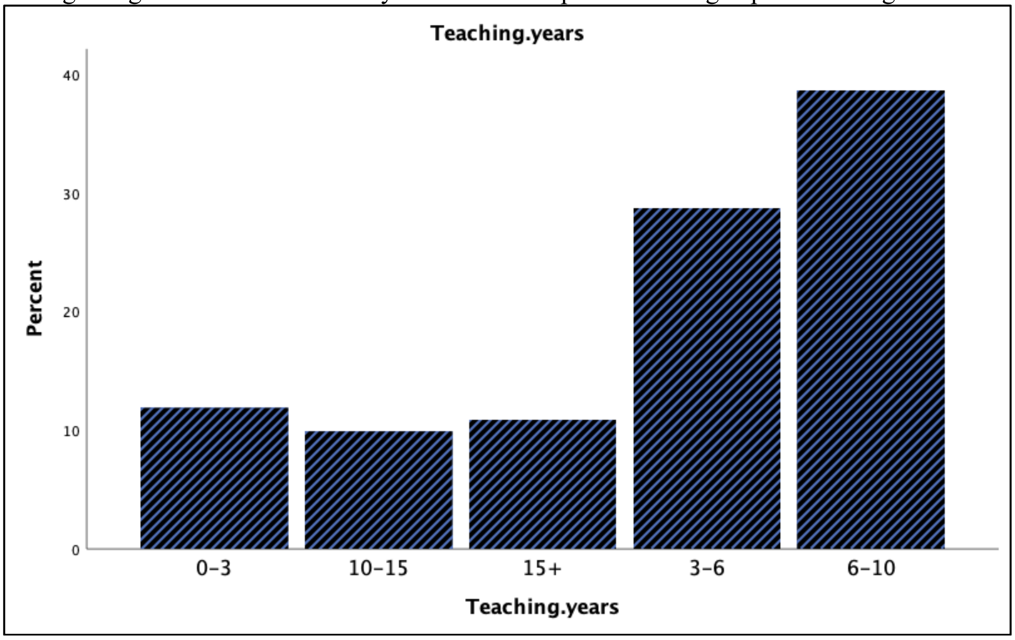

Figure 3. Years of teaching experience of TBA participants

The educational background of participants varied, such that 51.5% had undergraduate degrees and 48.5% had graduate degrees. Participants taught different school subjects, mostly identifying as elementary teachers (homeroom teachers in the US) (22.8%), or "Information Technology" teachers (19.8%). Most taught at the primary school level (39.6%), followed by the middle school level (29.7%).

Data Collection. The themes and subthemes constructed based on the interview analyses were used to create content categories for the survey. A descriptive table was created to include the themes, examples, and statement items of the survey. This table was reviewed by a subject-matter academic expert to re-organize the categories and statements of the survey to follow a coherent order. At this point, the survey was translated from English to Turkish to avoid language barrier with the target population. The survey was prepared online using Google Forms. The survey was printed out and discussed in a think-aloud session with five public school teachers as potential participants. A pilot test was conducted with ten participants who completed the survey using Google Forms. The participants in the pilot tests were public-school teachers' working in a primary school level of TBA.

The first section of the survey included demographic questions. Section two consisted of participants responding to statements regarding: (1) defining collaborative learning, (2) promoting professional development and CL, (3) designing projects/activities, (4) using strategies and resources, (5) assessing collaborative projects, (6) challenges and limitations, and (7) students' engagement and interaction. Each section included 3 to 5 items with each rated on a scale from 1 to 5 to reflect participants' level of agreement, experiences and/or knowledge. The survey was available online for approximately 3 weeks.

Data Analysis. The following flowchart displays the steps that were followed in this phase (See Figure 4).

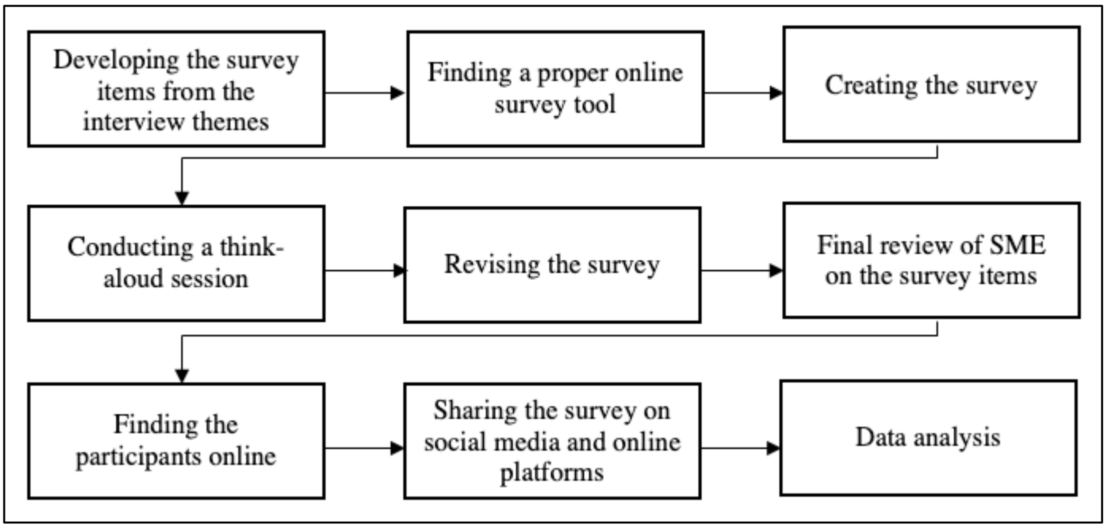

Figure 4. Flowchart for steps taken in phase 2.

Survey responses were uploaded as an Excel file and prepared for analysis (e.g., invalid responses were excluded, variable labels were added, etc.). After that, the Excel file was uploaded to SPSS. Reliability analysis was calculated as Cronbach alpha values, such that values above 0.90 are excellent, above 0.80 is good, above 0.70 is acceptable, and values below 0.70 are questionable to poor (George & Mallery, 2002).

Validity and Reliability. For the quantitative phase of the study, the survey items were created based on the themes and subthemes that were constructed from the qualitative data analysis. This technique was chosen to increase the validity and the reliability of the phase in the study (Abowitz & Toole, 2010). The items of the survey were also revised by an academic expert. Additionally, the researcher conducted a think-aloud session, a pilot test, and peer-examination to enhance the reliability of the study (Taherdoost, 2016). Finally, all the survey items (a total of 31 items) were analyzed in SPSS using the Cronbach reliability analysis. The latter showed "alpha=.92" which considered to be an excellent (George & Mallery, 2002).

Limitations. There were a few limitations identified during Phase 2. The survey was created in English then translated to Turkish. Second, most of the participants of the survey were in Istanbul. Therefore, the survey responds could change when reaching out to more K-12 TBA teachers in other cities of Türkiye.

FINDINGS

Phase 1: Interview Results

Makerspace experts from different countries were interviewed about collaborative learning in makerspaces. They discussed definitions, project creation, engagement strategies, assessment, and ways to promote collaboration among students. The qualitative analysis identified 8 themes and 38 subthemes, which are presented in Table 3 along with their frequencies.

Table 3. Themes and subthemes of the interview

Main Themes	Subthemes	Frequency	Total
Defining collaborative learning in makerspace	Learning opportunities	6	39
	Developing communicational skills	8	
	Interacting with tools/technology	5	
	CL definition in makerspace	12	
	Definition of collaborative learning	8	
Promoting collaborative learning in makerspace	Sharing experiences	7	12
	Project work	5	
Teachers' role in makerspace	Tool specialist	4	24
	Designer	2	
	Facilitator	13	
	Monitor	5	
Strategies for an effective makerspace	Project-based learning	7	56
	Scenario-based training strategies	5	
	Contributions and roles	6	
	Community building strategies	19	
	Communication	5	
	Personal experiences	14	
Assessing collaborative learning in makerspace	Observation	4	40
	Rubrics/Checklists	4	

	Traditional assessment	1	
	Self-assessment	14	
	Process	3	
	Design	7	
	Peer-assessment	7	
Challenges for maker-teachers	Assessment	4	42
	Establishing an interactive environment	8	
	Resources	7	
	Struggling with learning strategies	17	
	Motivation	6	
Overcoming challenges	Professional development	6	26
	Collaboration between teachers	3	
	Assigning roles	11	
	Implementing motivational activities	6	
Students' engagement in makerspace	Raising the competition	2	27
	Social learning activities/projects	12	
	Cross-disciplinary learning	3	
	Interest-based challenges	7	
	Maintaining diversity in roles	3	

Defining Collaborative Learning in Makerspace. In interviews, participants defined collaborative learning broadly and within makerspaces, yielding 39 relevant codes. Within makerspaces, collaborative learning creates a space for students to jointly work on projects, fostering social skills. The participants emphasized improved social and interpersonal abilities through shared responsibilities: “collaborative learning is actually based on social learning. And by saying collaborative learning you actually mean getting together with peers and working on something together for a purpose” (participant 7). Similarly, participant 9 highlighted the social foundation of collaborative learning, extending to “collaboration with tools and technology.” Makerspaces offer a distinct learning environment where collaborative learning occurs formally or informally, promoting interactive learning. Participant 6 stressed how makerspaces deepen “learning via hands-on creation.” Most participants emphasized the enhancement of conversational, communication, and problem-solving skills. For example, participant 2 shared: “this is a very open work/learning space where people feel like they can reach out to other people you know. There's a lot of conversation happening around and how you can do things better”. Overall, collaborative makerspaces encourage collective problem-solving and skill development, aligning with evolving learning science trends.

Promoting Collaborative Learning in Makerspaces. The interview analysis yielded 12 relevant codes pertaining to strategies for promoting collaborative learning in makerspaces. Participants suggested diverse approaches to foster collaboration among students. Participant 3 highlighted the value of introducing “distinguished projects and forming interest-based teams” to stimulate collaboration. Participants 1 and 2 emphasized the implementation of varied collaborative projects to cultivate teamwork and interaction skills. Participant 12 emphasized “encouraging diverse ideas and problem-solving” and creating a positive environment that embraces diverse ideas. Participant 10 highlighted the influence of management infrastructure on collaboration, citing “financial support and well-maintained spaces” as critical factors. Preparation for collaborative work was stressed by participant 10, advocating for “raising awareness and building students' teamwork abilities.” Additionally, participants 5 and 8 stressed the significance of integrating “real-life activities and projects,” enhancing collaboration skills, idea acceptance, and meaningful product creation.

Teachers’ Role in Makerspace. The qualitative analysis identified 24 codes related to teachers' roles in makerspaces. Four key roles emerged: 1) tool specialists, 2) designers, 3) facilitators, and 4) monitors. Related to the role of tool specialist, Participant 5 cautioned about the responsibilities and risks inherent in makerspaces, underlining the crucial “teacher-student collaboration in mastering tool usage.” Participant 1 highlighted the effectiveness of passionate teachers who actively “engage in making” themselves, fostering spontaneous collaborative learning.

Roles as designers were stressed by participants 5 and 11. Participant 5 urged teachers to co-explore and design code, providing informed guidance: “I would say teachers’ role should include more of guiding on the side or facilitator or co-explorer or code designer. Someone who is doing things with the learning process themselves”. Similarly, participant 11 emphasized teachers' role in “designing diverse makerspace projects and activities.” Facilitation also emerged as a pivotal role. Participant 1 emphasized teachers' role in “seeding ideas and modeling project processes,” particularly in entrepreneurial contexts. Participant 2 echoed this, highlighting “guiding and modeling within a value-based perspective.” Participant 5 reiterated the “value of teachers' facilitation” and expertise modeling, transforming teaching paradigms.

Related to their role as facilitators, Participant 7 stressed the art of providing timely support, “asking guiding questions instead of offering direct answers.” This approach, akin to cognitive apprenticeship, was also emphasized by participant 13, who underscored teachers' “responsibility to scaffold and motivate students.” Equally vital is teachers' observational and feedback ability, as noted by participants 7 and 12. Participant 12 highlighted teachers' roles as monitors, responsible for assigning tasks, tracking student progress, offering feedback, and fostering independent problem-solving “teachers should not tell the answers but should encourage students to overcome that struggle or that problem by themselves. So, teachers can ask questions and give feedback but do not tell what to do to solve the problem" This multifaceted teacher role dynamic emerged as a cornerstone in the collaborative and dynamic makerspace environment.

Strategies for an Effective Makerspace. The analysis of this interview section unveiled 56 codes outlining diverse strategies to cultivate effective makerspace environments. Participant 4 emphasized "project-oriented and technical-oriented strategies," stressing the importance of tool competence for interaction and creativity. Project-based and problem-based learning were highlighted as key components for fostering collaboration: "In my experience problem based and project-based learning is why students actually collaborate" (participant 4). "Scenario-based training" strategies, endorsed by participant 10, were deemed vital for "social, communicative, and technological skill acquisition," fostering engagement and tool understanding.

Community-building strategies emerged as a consensus among participants. Community-centric approaches, as advocated by participants 2, 5, 6, 9, 10, and 12, fostered problem-solving, idea exchange, and comfort. Participants 1 and 2 viewed community-building as a departure from traditional teaching, with participant 2 highlighting its role in team-oriented learning: "It is about having connections with other people and building a community. It is invigorating for both themselves as well as their creativity and so is the community itself". Participant 3 noted "strategy adaptation based on context," particularly formal or school settings. A comfortable environment for idea exchange was emphasized by participants 3, 7, and 8. Assigning roles to collect contributions in collaborative projects was endorsed by participants 6, 7, and 11, the latter stressing challenge-setting and stepping back for non-traditional, team-oriented problem-solving. Participant 7 accentuated the importance of fostering social emotional learning and community support beyond authoritative figures. These strategies collectively outline multifaceted approaches to nurture collaboration and creativity within makerspace environments.

Assessing Collaborative Learning in Makerspace. The interview analysis revealed 50 codes addressing strategies for assessing collaborative projects in makerspaces, yielding seven subthemes. Self-assessment was a prevailing technique, as multiple participants underscored its value in gauging learning progress and skills acquisition. Participant 4 introduced a "longitudinal assessment with reflection," fostering insight into students' growth. "Exhibition or presentation formats" (participant 10) facilitated sharing experiences, encouraging improvement. Peer assessment, while debated, showed promise for understanding teamwork (participants 4,10), yet concerns were raised regarding bias and discomfort (participants 5, 13). Observation emerged as effective in capturing interactions and critical thinking (participants 9, 11). "Assessing the learning process," rather than the outcome, was highlighted by participant 11, aligning with participants 2 and 4's emphasis on interactions with tools and materials. Strategies to avoid included traditional assessments (participants 7,10) that risked stifling creativity, and rubrics/checklists (participant 7) that could divert focus from meaningful learning. These findings collectively provide multifaceted insights into assessing collaborative learning in makerspaces.

Challenges for Maker-Teachers. The interview analysis yielded 42 codes addressing the challenges maker-teachers face when fostering collaborative makerspace environments. These challenges revolved around assessment, interactivity, resources, learning strategies, and motivation. Many participants highlighted that learning strategies posed significant challenges, with personal background experiences potentially causing shifts to traditional teaching methods instead of learner-centered approaches (participants 1, 8,11). Lack of prior makerspace training and knowledge could hinder effective teaching (participants 10, 11, 12), affecting motivation and student engagement. Establishing interactive spaces posed difficulties, particularly when managing multiple groups and ensuring equal participation (participants 3, 9,13). Resource constraints were flagged as challenging (participants 3, 12), with "funding impacting the sustainability and innovation of makerspaces" (participant 9). Assessment complexities were also stressed, as participants 2, 3, and 13 highlighted the struggle to determine effective assessment methods tailored to makerspace projects. These findings underline the multifaceted challenges that maker-teachers confront in creating dynamic collaborative makerspace environments and assessing students' learning in those spaces.

Overcoming challenges. The interview analysis revealed 26 codes highlighting the consensus on continuous self-improvement and development for teachers to effectively navigate challenges in makerspaces and collaborative learning. Participants emphasized that "ongoing practice and building experiences" (participant 11), attending online seminars (participants 7,10), workshops on tools and technologies (participant 7), and maintaining a reflection journal (participants 5, 7) were essential for growth. "Pursuing degrees or educational programs specializing in makerspace approaches" (participant 1) was advocated, fostering confidence and empowering teachers to apply innovative pedagogies. Joining teachers' communities and forums to share ideas and experiences (participants 7,12), as well as promoting "teamwork among teachers" for collaborative activity creation (participant 7), were recommended approaches. These findings underscore the significance of continual teacher development in successfully implementing collaborative makerspace environments.

Students' Engagement in Makerspace. In this study, the analysis of interviews showed 25 codes that highlighted the paramount role of interaction within makerspaces. These codes were categorized into five subthemes: raising competition, social-learning activities, maintaining diversity, cross-disciplinary learning, and the interest-based challenges framework. Participants underscored how raising competition through challenges and activities spurred engagement and interaction among students (participants 5, 9). Social-learning activities were seen as potent in enhancing social skills, empathy, and community-building, fostering a sense of belonging (participants 3, 11, 13). Diversity was deemed vital, as it facilitated the formation of groups with differing profiles, enriching discussions, and collaboration (participants 5, 10). Cross-disciplinary learning was recognized for its role in engaging students with diverse backgrounds and interests (participant 4). The interest-based challenges framework was identified as a dynamic approach to stimulate interaction and teamwork by aligning tasks with students' passions and interests (participants 2, 3, 12). These findings underline the multifaceted ways interaction can be fostered within collaborative makerspace environments.

Phase 2: Survey Results

The survey items were derived from the themes and subthemes identified during the interviews. Although some themes were merged in the survey, the findings in this section are reported based on the survey themes. Notably, the survey was conducted in Turkish to accommodate the non-English language proficiency of the target population, primarily public-school teachers engaged in TBA. Consequently, the items were translated from Turkish to English for the presentation of results.

Defining Collaborative Learning. This section of the survey encompassed 3 items and received responses from 101 participants. The Cronbach alpha analysis yielded a value of "0.79" for this section, indicating an "acceptable" level of reliability according to George and Mallery's (2002) criteria. The mean of the 3 survey items indicated an average of "4.74," reflecting participants' general inclination to "strongly agree" with the items in this section (see Table 4).

Table 4. Descriptive analysis for the section on "defining collaborative learning."

	Mean
Collaborative learning creates learning opportunities for students.	4.77
Collaborative learning provides opportunities for students to develop their communication skills.	4.78
Collaborative learning can occur between student and technology. (For example, 3D printer or computer etc.)	4.69

In essence, the findings unveiled that TBA teachers concurred on the importance of collaborative learning as a pivotal approach for effective education. The survey results highlighted that collaboration fosters improved learning opportunities, communication skills, and the potential for collaborative learning between students and technology in makerspace-like settings.

Promoting Professional Development and Collaborative Learning. This survey segment comprised 4 items, garnering responses from 101 participants. The Cronbach alpha value analysis for this section yielded a score of "0.87," signifying a "good" level of reliability according to George and Mallery's (2002) criteria. The mean of the 4 items was calculated as "3.89," indicating that respondents predominantly regarded the techniques mentioned in this section as effective for fostering collaboration and their personal development in TBA (see Table 5).

Table 5. Descriptive analysis of the section on "promoting professional development and collaborative learning."

	Mean
I exchange project ideas in online forums with other TBA related teachers.	3.72
I attend professional development programs (e.g., training, workshop) to improve my "design and skills lab" related knowledge and skills.	3.83
I promote collaborative learning in my school by sharing my personal experiences with my colleagues.	3.99
I promote collaborative learning by demonstrating the benefits of working in teams interactively in a learning environment.	4.04

In essence, the findings underscored that participants recognize the significance of promoting collaborative learning and engaging in professional development to enhance their TBA-related knowledge. The survey results reflected that attending workshops, sharing experiences with colleagues, and demonstrating the benefits of teamwork contribute to fostering collaborative learning in educational settings.

Designing Projects and Activities. This section of the survey aimed to capture teachers' understanding of their roles in designing collaborative projects and activities in TBA environments. The survey consisted of 3 items, with 101 participants responding. The Cronbach alpha value for this section was calculated as "0.86," indicating a "good" level of reliability based on George and Mallery's (2002) criteria. The mean of the 3 items in this section was computed as "4.00," suggesting that most participants possessed a "good" understanding and knowledge of designing projects and activities in collaborative DSL environments (see Table 6).

Table 6. Descriptive statistics for the section on "designing projects/activities."

	Mean
I know how to apply project-based learning in Design and Skills Labs.	3.87
I know how to design real life project ideas for Design and Skills Labs.	3.94
I know how to prepare enjoyable activities (for example, games, handicrafts) that will attract students' attention in Design and Skill Labs.	4.21

The findings indicated that TBA teachers have a "good" understanding of how to apply project-based learning, design real-life projects, and prepare engaging activities that capture students' attention in TBA environments.

Using Strategies and Resources. This section of the survey delved into teachers' understanding and utilization of strategies and resources in TBA. The survey comprised 5 items, with 101 participants responding. The Cronbach alpha value for this section was calculated as "0.90," reflecting an "excellent" level of reliability according to George and Mallery's (2002) criteria. The mean of the 5 items in this section was calculated as "3.91," signifying that most participants exhibited a "good" understanding and knowledge of using strategies and resources in TBA environments (see Table 7).

The findings highlighted that public school teachers demonstrated a "good" understanding of using strategies and resources, including problem-based scenarios, assigning roles, communication, facilitation, and utilizing tools and technologies in TBA environments.

Table 7. Descriptive statistics for the section on "using strategies and resources."

	Mean
I know how to use problem-based scenarios for my students to solve the given problems as a team.	3.38
I know how to assign roles (e.g., team leader, designer, researcher, etc.) to my students while working on team projects.	4.01
I know how to communicate with my students during team projects.	4.07
I know how to facilitate students' learning tasks (e.g., showing examples, asking questions) in team projects.	4.07
I know how to use the tools and technologies provided in the design and skills workshops.	4.05

Assessing Collaborative Projects. This section aimed to explore teachers' knowledge of assessment strategies for evaluating students' learning from collaborative projects. The survey consisted of 6 items, and 101 participants responded. The Cronbach alpha value for this section was calculated as "0.92," indicating an "excellent" level of reliability based on George and Mallery's (2002) criteria. The findings underscored that TBA teachers exhibited a "good" understanding of various assessment techniques, including the use of rubrics, progress reports, individual evaluations, peer reviews, and evaluation of team project results, to evaluate students' learning from collaborative projects (see Table 8).

Table 8. Descriptive statistics of the section on "assessing collaborative projects."

	Mean
I know how to use rubrics to evaluate what my students have learned in team projects.	3.91
I know how to use the student progress report card based on my observations during a team project.	4.02
I know how to evaluate the learning process of students in project-based teamwork.	4.02
I know how to evaluate my students individually in teamwork.	4.02
I know how to use the peer review strategy to get my students to give feedback to each other.	3.99
I know how to evaluate students' team project results (final product).	4.00

Challenges and Limitations. In this section of the survey, participants were asked to address the challenges and limitations they encounter when implementing collaborative learning strategies in TBA. The survey consisted of 5 items, and all 101 participants provided responses. The Cronbach alpha value for this section was calculated as "0.78," indicating an "acceptable" level of reliability based on George and Mallery's (2002) criteria.

Table 9. Descriptive statistics of the section on "challenges and limitations"

	Mean
I find it difficult to decide on the right strategy (For example, discussions, group work, group competition, etc.) when implementing collaborative learning activities in design and skills labs.	4.05
I find it difficult to attract my students' attention to team projects.	4.11
I find it difficult to create a collaborative learning environment in design and skills labs.	4.12
I find it difficult to evaluate my students' individual contributions to team projects.	4.10
I find it difficult to access resources (for example, supporting documents and materials) to help my students' learning process in the design and skills labs.	4.15

A descriptive analysis of the responses revealed a total mean of "4.10" for this section, suggesting that most participants responded with "often" when addressing the challenges and limitations related to implementing collaborative learning strategies in TBA environments. The findings indicated that public-school teachers commonly face challenges related to selecting appropriate strategies (see Table 9), capturing students' attention, creating a collaborative learning environment, accessing resources, and evaluating individual contributions within team projects in TBA environments.

Student Engagement and Interaction. This section explored teachers' experiences in promoting students' engagement and interaction in collaborative work or projects within DSL environments. The survey included 5 items, and all 101 participants responded. The Cronbach alpha value for this section was calculated as "0.85," indicating a "good" level of reliability based on George and Mallery's (2002) criteria. The descriptive analysis revealed a total mean of "4.17" for this section, indicating that most participants "agree" that the techniques and strategies outlined in the items facilitate students' engagement and interaction in TBA (see Table 10).

Table 10. Descriptive statistics of the section on “students’ engagement and interaction”

	Mean
My students interact better when they produce joint projects based on their interests.	4.09
My students interact better when I implement projects based on real-life.	4.17
My students interact better when I group them according to their profile (for example, their personalities and learning styles).	4.24
My students interact better when I use projects from different fields.	4.16
My students interact better when I create challenges and competitions with rewards to solve given problems as a team.	4.21

The findings highlighted strategies such as tailoring projects to students' interests, implementing real-life projects, grouping students based on profiles, utilizing projects from different fields, and introducing challenges and competitions contribute to students' better interaction and engagement within collaborative learning scenarios in TBA.

DISCUSSION

The following section provides an in-depth discussion of the results that were constructed in the previous section.

Collaborative Learning

This study underlined the importance of collaborative learning for how it promotes social skills, interaction, and the construction of knowledge and learning among students. The participants highlighted that collaborative learning is an important component to improve communication and socialization abilities. These findings are consistent with Kaendler et al (2015) study which identified collaboration as an element that brings students together and provides opportunities for students to benefit from each other’s skills while solving a problem or completing a task. Christie (2000) and Lai (2011) also underlined collaborative learning as beneficial to create a socialized-based environment that targets improving students’ skills and social abilities. The latter is stated to be helpful in creating an environment where students exchange ideas and experiences. Similarly, the socio-cultural theory of Dewey (1986) discussed these experiences to be fruitful when they occur in a “supportive environment”. This environment is described to be supplied with the right strategies that targets collaboration through problem-solving and creativity (Dewey, 1986). The participants in both phases also reported that collaboration can occur in a student-tool situation. In other words, students can collaboratively interact with the tools and technologies provided in the space while exchanging ideas and expertise among each other (Barett et al., 2015). In a similar context, Burke (2018) stated that students are not divided by a system, but instead they come together as a community.

Strategies and Resources

The results of this study highlighted three strategies and resources that would ensure students’ engagement and collaboration in a makerspace environment. The first strategy is project-based learning (PjBL). The makerspace experts in this study underlined the importance of maker-teachers in understanding collaboration strategies and implementing them in makerspace environments. This idea aligns with the constructivist theories presented by Von Glaserfled (1989) and Savery & Duffy (1995) which promote learning while students are actively engaged in knowledge construction throughout the process. This would also allow the establishment of collaborative student-centered environment (Savery & Duffy, 1995). Moreover, the application of PjBL in makerspaces increases opportunities for students to improve skills like leadership, problem-solving, critical thinking and creativity while working on real-world projects (Huysken et al., 2019). The DSLs teachers in this study expressed their understanding and knowledge of PjBL activities but notes challenge when such activities are incorporated in a makerspace environment. We speculate that challenges arise from (1) a lack of teacher experiences/training and (2) lack of experience in managing groups in an environment such as in makerspace. The second strategy is problem-based learning (PBL). The promise of PBL in makerspace environments was noted by both makerspace experts and TBA teachers, suggesting the usefulness of PBL in creating an opportunity for students to develop skills such as critical thinking, problem-solving, and communication (Barkley et al., 2014). Such skills are honed while students work among each other while interacting with research and materials (Barkley et al., 2014). Moreover, PBL was perceived to enhance students' encouragement for learning as it integrates intrinsic motivation (Huysken et al., 2019). PBL is also underlined as key component in makerspaces to build the community spirit through the learning process in its social interaction approach (Kokotsaki et al., 2016). Similarly, Schmidt (1983) and Huysken et al. (2019) mentioned that community-based environments create a comfortable space for students that is based on the sense of belonging, sharing, and trust. The participants also expressed the importance of implementing real-life based projects to improve students' cognitive and social skills. Barrett et al. (2015), similarly stated that real-world situations are the essential basis for PBL in any learning environment as they direct an educational structure that is tied to integrate the 21st century skills. However, some experts and DSL teachers pointed out that a lack of training and previous experiences can interfere with the implementation of PBL in makerspaces. Teachers' tendency to teach might raise challenges in integrating PBL effectively in makerspace environments (Barett et al., 2015). The final strategy is assigning roles. The makerspace experts in the present study reported that assigning roles ensures the fair participation and engagement of each student in the learning environment. Gu et al. (2015) presented similar results underlining that assigning and modelling roles ensure the distribution of responsibilities among individuals which encourage students in contributing ideas and feel responsible to their groups. Nevertheless, Wang (2009) explained that for this strategy to work, teachers must determine the roles that are needed in the groups and provide an explanation before assigning them. However, not all research supports the assignment of student roles in collaborative learning environments. Soller (2001) expressed that in some cases assigning roles can create conflicts as some students can be overshadowed by others who tend to be more dominant. Students may become less confident to share ideas or contribute to their groups. Therefore, Gu et al. (2015) stated that teachers must consider students' personality profiles to be grouped properly while they – teachers – continuously monitor the learning process.

Assessment in Collaborative Learning

Four techniques were identified to assess students' learning from collaborative projects in makerspaces and similar environments.

Rubrics. The makerspace experts in this study underlined rubrics to be weak and insufficient to evaluate students' learning process and outcomes. Similarly, Pandero and Romero (2014) discussed rubrics to raise difficulties for students to match certain criteria. Therefore, rubric-based assessments tend to limit students' creativity (Brookhart, 2013). Students feel obliged to follow tasks and projects based on the rubrics' outlines which eliminate areas of imagination and creativity (Brookhart, 2013). Blaz (2013) also added that rubrics are effective to assess writing tasks; however, they are ineffective to evaluate students' creativity, communication, problem-solving, and critical thinking skills. All of which are important skills in makerspaces environments. Cross's (2017) study contradicts with these finding as it stated rubric-based assessment are reliable and allow better areas for peer-feedback. Further, Soster et al. (2020) mentioned that rubrics in makerspaces should address the performances which are expected to be mastered by students without limiting areas for creativity.

Observation. The findings constructed from the participants highlighted observation to be an effective assessment tool for students' collaboration and learning progress in makerspaces environments. This aligns with Kumar et al. (2019) that underlined observation to be successful to support real-time organization and increase the granularity of the data. This is done while the observer interacts with the actions that needs to be observed and provide better accuracy (Kumar et al., 2019). Hobart & Frankel (2004) similarly see observation to allow teachers to track students' progress, determine students' difficulties, and produce areas of reflection for future plannings. However, Cooke et al. (2003) controvert with these findings with stating that observation is ineffective and not reliable to understand students' learning progress. Using observation to assess students' attitudes and interactions can be ineffectual as they are directed with the time and the place of the task. Nevertheless, when teachers are provided with trainings on areas of observation in makerspace, it is believed that observation could be a strong assessment tool (Kumar et al., 2019).

Self-Assessment. The participants in this study underlined self-assessment to be one of the most productive evaluation tools in makerspace and similar environments. Colthart's et al. (2008) study shows self-assessment to be a purposeful tool for students to be engaged in the learning process, while disagrees their work achievements on their own. This idea provides students with opportunities to determine their learning challenges, strengths, weaknesses, and knowledge while still allowing areas for development (Colthart et al., 2008). Self-assessments also reduce students' discomfort of being assessed by another individual or a tool (Ekbatani & Pierson, 2012). Therefore, this technique could be done as a reflection paper, presentation, or even an exhibition (Ekbatani & Pierson, 2012). On the other hand, Möller (2022) states that self-assessment may be subjective. Students tend to over-evaluate or under-evaluate themselves when presented with criteria. However, this seems to depend on teachers' choice of the way to conduct self-assessment as it seems to be more challenging only when presented as a checklist. Modelling the assessment strategy may reduce complications of bias, and time-consumption (Jones, 2006; Möller, 2022).

Peer-Assessment. The experts in this study mentioned peer-assessment to be an important tool to encourage collaborative work. TBA teachers similarly expressed their comprehension and knowledge of design peer-assessment materials. Peer assessment provides chances for students to assess each other's performances while improving their analytical, listening, and problem-solving skills (Möller, 2022). In a similar line, Topping (2009) described peer assessment as effective in providing feedback that approve existing information, describing made errors, improving informational application, and helping the expansion of theoretical schemata (Butler & Winnie, 1995). However, some of the experts in this study expressed concerns that peer-assessment can be ineffective as it could be biased or make students uncomfortable to assess each other's performances. Topping (2009) stated in this regard that individuals feel discomfort about peer-assessment because of the relationships among students. Hence, peer assessment could be unreliable as it could make students feel nervous about evaluating another peer as it may create social criticism. However, organized peer-feedback shows better reliability and less bias conflicts (Topping, 1989).

Promoting Professional Development

In the findings, the participants expressed many challenges that teachers encounter in makerspaces environments. These challenges centered on understanding the needed strategies to design projects, assessment tools, and the needed resources to facilitate students' learning in makerspaces environments.

Collaborative Learning Strategies. The survey indicated TBA teachers understanding of collaborative learning (CL) strategies while still encountering them as challenges in makerspaces environments. The experts in this study pointed out teachers' tendency to teach as one factor to create these obstacles. Bencze et al. (2006) underlined similar context by mentioning that teachers' tendency to "teach" could create a challenge to implement collaborative strategies effectively in makerspaces. Therefore, teachers should understand their roles in creating a learner-centered environment and facilitate the learning process to enhance students' understanding of learning and creating (Hira et al., 2014). Structuring CL project activities is another challenge for teachers. Lacking in constant monitoring of students' behavior while conducting tasks, groups time management, presenting related materials, and establish teamwork spirit among members (Gillies & Boyle, 2010). Similarly, Ha Le et al. (2018) highlighted that teachers focus on the cognitive side of collaboration instead of its collaborative aspect. Hence, teachers' incompetency to implement successful collaborative strategies affect students' learning and interaction among their groups. PjBL and PBL are also discussed to be effective strategies that allow students to work in groups while developing skills, construct knowledge, and share learning experiences. Therefore, teachers should be supplied with pre- and in-service trainings to implement CL effectively in TBA.

Assessment Tools. In both phases the participants mentioned concerns about assessment tools to be challenging to implement in makerspaces environments. Kumar's et al. (2019) study introduced that recording observation can be useful to organize events and give feedback to assess collaboration and learning in makerspaces. Assessing CL is based on the learning experience, progresses, and social interactions (Hunter, 2006). MIT presented embedded assessment projects for maker education. This "beyond rubrics" project is for an ongoing formative assessment method that is based on performances, flexibility, and playfulness (Chang, 2018). This technique allows students to self-assess themselves while reflecting on their work of learning processes and outcomes (Chang, 2018). Previous studies also suggested that assessment can be effective when it is collected through varied sources. This would allow to evaluate soft skills, hard skills, the design process, community interaction, and content application (Oliver, 2016). Additionally, collaboration among teachers allow facilitation and feedback for tasks before implementation. Documenting the process was suggested to improve teachers' performance. This would be helpful for teachers to implement effective assessment tools along with which skills to evaluate (Oliver, 2016; Chang, 2018).

Resources. Accessing resources and materials was identified as another primary challenge, and it poses obstacles for teachers in addressing students' needs within the learning environment. Makerspaces depend on their equipment to address the varied learning experiences, along with constant maintenances which could be expensive (Slatter & Howard, 2013). Moorefield-Lang (2015) highlighted finance to be challenging in maintaining makerspaces supplies, costs, and resources. Therefore, the proper funding of these makerspaces environments should be taken into consideration by responsible individuals to allow a smooth function. Additionally, the findings underlined the relationship between teachers and tools/materials to be similarly important. That said, raising awareness on "how" and "which" tools to use is essential to avoid risks in such an environment. Following this regard, Litts (2015) emphasized maker teachers training to be able to instruct and model tools (e.g., cables, 3D printers, laser cutters, etc.) without putting themselves or students in danger. The powerless-power transmission is suggested in Bensenouci & Brahimi's (2017) study as an effective tool for makerspaces, because it is supplied with less cables, plugs, and sockets which would increase the amount of safety in makerspaces environments (Bensenouci & Brahimi, 2017).

CONCLUSION

Collaborative learning is an approach that supports students' communication and skill development. The social constructivist theory aligns with the integrative model in conveying the necessity of knowledge construction and creativity in a student-centered environment. In makerspaces, CL includes interacting with the materials and the technologies provided in the space. Despite the positive aspects noted about CL, TBA teachers in this study expressed lacking background training and experiences in makerspaces environments. Therefore, implementing CL effectively in makerspaces continues to raise challenges for maker-teachers. However, strategies like PjBL and PBL provide useful approaches to support students' learning in makerspaces environments. These strategies promote the development of skills like problem-solving, critical thinking, creativity, and leadership. Nevertheless, assigning roles must be considered to prepare students for collaboration and ensure their engagement with the learning projects and activities. Formative self-assessment is underlined to be useful as it raises students' self-critics to point their achievements and areas of development. Recorded observations can also facilitate learning progress and interactions. Meanwhile, peer-assessment and rubrics must first be designed in an unbiased way to avoid students' subjectivity when implemented. Including multiple assessment techniques is by far suggested to be the best way to understand students' learning outcomes and skills development in makerspaces and similar environment. The latter could be a variation of observation, peer-assessment, self-reflection and rubrics altogether. Nevertheless, this study highlights teachers' needs for professional development and trainings on the effective implementation of collaborative learning strategies and assessment tools in the design and skills labs. Furthermore, providing dedicated fundings to access equipment, materials, and resources in makerspaces and similar environments like TBA would ensure the continuous integration of these spaces and provide a more meaningful experience for both learners and maker-teachers.

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APPENDICES

Appendix A. Invitation to the study

Dear Dr. ……………….,

I am conducting a research study investigating experts' understanding of collaborative learning in makerspaces and similar environments (as the first phase of a longitudinal study)
In this regard, I am kindly inviting you to become one of our voluntary participants for a semi-structured interview. The interview will total take an approximate duration of 30 to 40 minutes to simply get your thoughts and perspectives about the topic.
I would appreciate your reply if you accepted our invitation. With your acceptance, I will send you another email with details about the dates and times of an interview to choose in your convenience.

For your replies and any further questions, you can reach me via the following email addresses:

Kind regards,

Appendix B. Consent form

INFORMED CONSENT FORM
Adapted from: Stanford University *Available at: https://web.stanford.edu/group/ncpi/unspecified/student_assess_toolkit/pdf/sampleinformedconsent.pdf*

<u>Consent for Participation in an Interview Research for a Thesis Study Paper</u>

I volunteer to participate in the thesis research project. I understand that the project is designed to gather information to investigate and explore teachers' understanding on Collaborative Learning and Teamwork Strategies in the Design and Skill Labs.

1. My participation in this project is voluntary. I understand that I will not be paid for my participation. I may withdraw and discontinue participation at any time without penalty.

2. I understand that most interviewees will find the discussion interesting and thought-provoking. If, however, I feel uncomfortable in any way during the interview session, I have the right to decline to answer any question or to end the interview.

3. Participation involves being interviewed by the researcher. The interview will last approximately 20 to 30 minutes. Notes will be written during the interview. A recording of the interview and subsequent dialogue will be made. If I don't want to be recorded, I will not be able to participate in the study.

4. I understand that the researcher will not identify me by name in any reports using information obtained from this interview, and that my confidentiality as a participant in this study will remain secure. Subsequent uses of records and data will be subject to standard data use policies which protect the anonymity of individuals and institutions.

5. Administrators from my campus will neither be present at the interview nor have access to raw notes, records, or transcripts. This precaution will prevent my individual comments and the information obtained from the participants to be having any negative repercussions.

6. I have read and understand the explanation provided to me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this research study.

7. I have been given a copy via email of this consent form.

My name:

Signature of the researcher

Signature

Appendix C. Interview questions

- Based on your respective experiences, how would you define of a collaborative learning environment?
- How would that definition be relevant or differ in a collaborative learning makerspace environment?
- In your opinion, what collaborative learning strategies are more effective in a makerspace?
- How would you describe teachers' roles in an effective collaborative makerspace environment?
- What do teachers need to know to create a collaborative makerspace environment? (optional)
- What sort of challenges that maker-teachers may encounter when implementing collaborative student projects?
- How would you describe the ways or things that Maker-teachers should keep in mind to overcome these challenges?
- In your view, how could teachers promote collaborative learning in a makerspace environment?
- Do you think SS have problems understanding collaborative work? (optional)
- How can a Maker-teacher ensure students' engagement in collaborative projects?
- What strategies teachers could use to assess students' learning working on collaborative projects?
- If you had a chance to observe students in a collaborative makerspace environment, how would you define that experience?

Appendix D. Survey for public-school teachers in TBA

The link below is attached to provide access to the survey in Turkish, which was used to collect data in the quantitative phase.
Link: https://docs.google.com/forms/d/e/1FAIpQLSezw-ctiivtXxL0ZMn2KHvjFhnZgIr-fFx-_pRF2bDZj2JIsg/viewform?usp=pp_url

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Teacher's Understanding of Collaborative Learning Strategies and Teamwork in Design and Skills Labs
This survey is part of a thesis research that explores teachers' understanding on collaborative learning and teamwork strategies in makerspace in Design and Skills Labs. The context of this study is the DSLs (TBA) following the concept of Ministry of National Education's (MEB) establishment of these spaces among the K-12 levels in public schools. As a teacher with TBA is your school, you are invited to participate in this study via social media.
Your confidentiality will be preserved when sharing the results of this survey. Also, you can freely withdraw your participation whenever you want. Responses to this survey will take a total time of 10 minutes.
50tl Starbucks gift card will be sent to 5 teachers in a raffle that for teachers volunteering to participate in this study
MEdS Graduate student

Contact information.

Participants' Agreement

My school has TBA and I agree to voluntarily participate in this study.
There is no TBA at my school.
I do not agree to voluntarily participate in this study.

Page 2/ 11
Demographic Questions

- Your age:
- Your gender: Male/ Female/ Non-binary
- Educational background: undergraduate/ graduate / doctorate
- How long have you been teaching: 0-3/ 3-6/ 3-10/ 10-15/ 15+
- Which city are you teaching in: (Cities in Turkey are listed)
- Which levels are you teaching: pre-school/ elementary school/ middle school/ high school/ other …
- Which subject are you teaching: (school subjects are listed with option to choose "other" and type the subject)
- I have used DSLs (for example: in project development or lessons): Yes/ No
- I had trainings on DSLs: Yes / No
- If you currently have experience with your students or received training in DSLs, could you briefly describe your experience?

Page 3/ 11
Defining collaborative learning
Scale: Strongly agree/ agree / neutral/ disagree/ strongly disagree

- Collaborative learning creates learning opportunities for students.
- Collaborative learning provides opportunities for students to develop their communication skills.
- Collaborative learning can occur between student and technology. (For example, 3D printer or computer etc.)

Page 4/11
Promoting collaborative learning and professional development
Scale: Always/ often/ sometimes/ rarely/ never

- I exchange project ideas in online forums with other TBA related teachers.
- I attend professional development programs (e.g., training, workshop) to improve my "design and skills lab" related knowledge and skills.
- I promote collaborative learning in my school by sharing my personal experiences with my colleagues.
- I promote collaborative learning by demonstrating the benefits of working in teams interactively in a learning environment.

Page 5/11
Designing project/activities
Scale: very good/ good/ average/ little/ nothing

- I know how to apply project-based learning in Design and Skills Labs.

- I know how to design real life project ideas for Design and Skills Labs.
- I know how to prepare enjoyable activities (for example, games, handicrafts) that will attract students' attention in Design and Skill Labs.

Page 6/11
Using strategies and resources
Scale: very good/ good/ average/ little/ nothing

- I know how to use problem-based scenarios for my students to solve the given problems as a team.
- I know how to assign roles (eg team leader, designer, researcher, etc.) to my students while working on team projects.
- I know how to communicate with my students during team projects.
- I know how to facilitate students' learning tasks (eg showing examples, asking questions) in team projects.
- I know how to use the tools and technologies provided in the design and skills workshops.

Page 7/11
Assessing collaborative projects
Scale: very good/ good/ average/ little/ nothing

- I know how to use rubrics to evaluate what my students have learned in team projects.
- I know how to use the student progress report card based on my observations during a team project.
- I know how to evaluate the learning process of students in project-based teamwork.
- I know how to evaluate my students individually in teamwork.
- I know how to use the peer review strategy to get my students to give feedback to each other.
- I know how to evaluate students' team project results (final product).

Page 8/11
Challenges and restraints
Scale: Always/ often/ sometime/ rarely/ never

- I find it difficult to decide on the right strategy (For example, discussions, group work, group competition, etc.) when implementing collaborative learning activities in design and skills labs.
- I find it difficult to attract my students' attention to team projects.
- I find it difficult to create a collaborative learning environment in design and skills labs.
- I find it difficult to access resources (for example, supporting documents and materials) to help my students' learning process in the design and skills labs.
- I find it difficult to evaluate my students' individual contributions to team projects.

Page 9/11
Students' participation and interaction
Scale: Strongly agree/ agree / neutral/ disagree/ strongly disagree

- My students interact better when they produce joint projects based on their interests.
- My students interact better when I implement projects based on real-life.
- My students interact better when I group them according to their profile (for example, their personalities and learning styles).
- My students interact better when I use projects from different fields.
- My students interact better when I create challenges and competitions with rewards to solve given problems as a team.

Page 10/11
Starbucks gift card raffle participation

- I would like to participate in the Starbuck's Gift Card raffle: Yes/No
- I want the results of the study to be shared with me and my views on the results to be received: Yes/No
- If you would like to participate in the Starbucks gift card raffle or would like the results to be shared with you, please complete the details below.
- Name:
- Mail address:
- Phone number:

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Submit the survey
Thank you for your time. Please complete the survey by clicking on submit.