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From makerspaces to language spaces: An investigation into Maker Education in EFL

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Abstract

Language learning and teaching is under increasing pressure from stakeholders to adapt and evolve in response to changing policies, rapid technological advances, and evolving needs. There is pressure to add more value to language teaching and learning by integrating content and skills instruction. In many contexts, such as schools, community centers, and libraries, a new educational approach, Maker Education, which focuses on learning through constructing hands-on projects, is an effective way of building learner's skills and content knowledge (Bevan, 2017; Martin, 2015). Researchers have noted Maker Education's potential for language learning, as it situates language in an immediately relevant context (see Dubreil & Lord, 2021). However, little research has been done on whether the Maker Education approach can maintain its efficacy in English language learning contexts. Accordingly, this paper will explore a Maker Education approach based on core principles derived from established Maker Education frameworks in a Content Language Integrated Learning context. Participants (n = 129) participated in Maker Education activities and immediately reflected on their experiences. The reflections were analyzed for evidence and alignment to the core constructs, showing strong support for Maker Education's capability to help learners develop skills and competencies even in a language learning environment.

Keywords: Maker Education, language learning, EFL, tertiary education

Introduction

Tertiary language education has faced a transformational dilemma in many countries worldwide. Whereas in the past, simply attaining fluency in a language was a laudable achievement, English competency is now only a single facet of learners' education. Language skills alone are insufficient to ensure competitiveness in the modern workforce (see Erdoğan, 2019). Additionally, as English language education has slowly penetrated earlier and earlier into the educational system in countries like Japan, the expectation is now that learners will have a strong foundation in English by the time they reach higher education. Accordingly, experts argue that graduates need more than language; they need real, actualizable skills and specific knowledge for the workplace (Walkinshaw et al., 2017).

Many universities have responded to these pressures by integrating language and content instruction through approaches and methodologies like the popular approach, content and language integrated learning (CLIL). In addition to helping students develop content and language proficiency, CLIL, researchers have shown that it can help foster the development of soft skills like critical thinking, problem-solving, and collaboration (see Vilkancience, 2011). However, these benefits only occur when the approach is clearly defined and based on sound methodologies. Methods that structure the triple integration of language, content, and skill development are needed.

To search for a solution, the researchers investigated Maker Education, an approach to project and problem-based learning that originated in the STEM (Science, Technology, Engineering, Mathematics) fields. Derived from the core tenets of makerspaces, "open, learning environments where students are able to design, create, innovate, and collaborate" (Tomko et al., 2018, p. 1), Maker Education involves students in collaborative, hands-on activities as part of the process of constructing knowledge. Maker Education draws heavily on constructivist principles wherein learners construct knowledge by forming "mental models from experience" (Oliver, 2016, p. 163). It also incorporates constructionism (Harel & Papert, 1991), which posits that learning occurs as students physically engage in a creative act that allows them to develop knowledge and understanding of concepts (Bevan, 2017). Additionally, the approach provides opportunities for students to learn content-area knowledge while developing skills like problem-solving and critical thinking (see Martin 2015). Accordingly, the researchers felt that the Maker Education approach has significant potential for contextualizing language, content, and skill development. This paper aims to contribute to the growing body of literature on Maker Education in language learning by examining what Maker Education can offer when employed in a CLIL learning context.

Literature review

Maker education

Making, "a process of creating something" (Hsu et al., 2017, p. 589), has long been associated with education. Froebel (1887), the originator of the concept of kindergarten, notably focused on building as a fundamental developmental and educational process, utilizing building blocks as a core component of his approach. Pragmatists like Dewey (1986) emphasized the importance of hands-on or experiential learning. Other theories, such as constructivism, highlight the formation of conceptual knowledge through interactions with objects (Valente & Blikstein, 2019). Another related model, constructionism, adds the idea "that this happens especially felicitously in a context where the learner is consciously engaged in constructing [a shareable artifact]" (Harel & Papert, 1991, p. 1). In constructionism, knowledge and concept formation are natural byproducts of the making process. Making became a worldwide phenomenon in 2005 when technological progress and the increasing availability of fabrication tools (Gershenfeld, 2005) led to the establishment of Fab Labs and Makerspaces, spaces containing tools and materials that are accessible to communities for completing projects (Hsu et al., 2017). As the "maker movement" (Hatch, 2014) spread and these spaces proliferated, the epistemological implications were quickly evident to educators, giving rise to the concept of Maker Education (see Peppler & Bender, 2013). Maker Education is an approach that emphasizes learner-initiated inquiry by creating hands-on projects using newly learned concepts and skills (Kurti et al., 2014; Lundberg & Rasmussen, 2018). The Maker Education Initiative (n.d.) defines Maker Education as "an approach that positions agency and student interest at the center, asking students to become more aware of the design of the world around them, and begin to see themselves as people who can tinker, hack and improve that design."

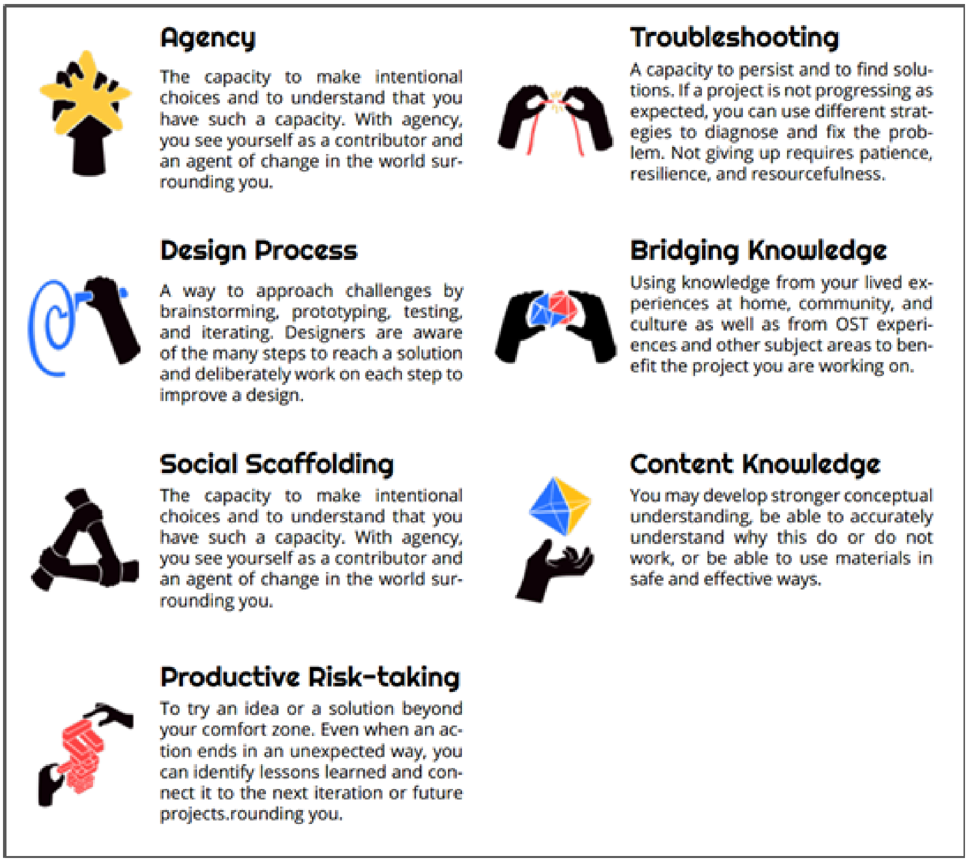
Proponents of Maker Education posit that the approach comes with a myriad of benefits beyond those which can be garnered through traditional instructionism paradigms (Harel & Papert, 1991). These benefits include but are not limited to:

- cultivating communication and collaboration skills (Martin, 2015),
- supporting student agency and self-regulation (Bevan, 2017),
- developing problem-solving skills (Shin, 2021, p. 62),
- fostering the development of a growth mindset (Bevan et al., 2015),
- deepening learning of content (Bevan & Wilkinson, 2014), and
- encouraging creative thinking (Weng et al., 2022).

To clarify the approach, researchers have developed frameworks such as Maker Elements (Maker Education Initiative, 2019; see Figure 1) and the Learning Dimensions of Making and Tinkering (Bevan et al., 2018).

Figure 1

The Maker Education Initiative’s maker elements



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Though each framework differs slightly, some commonalities highlight key aspects of the Maker Education approach.

- Maker education involves hands-on construction of a sharable item (Martin, 2015).
- It contextualizes learning in the process of solving meaningful problems (Maker Education Initiative, 2019).
- It is a social, collaborative process involving community (Cohen et al., 2017; Maker Education Initiative, 2019).
- It empowers learners with agency and choice in their learning (Cohen et al., 2017)
- It focuses on the process of making, with failure, feedback, and iteration being key components. (Cohen et al., 2017; Maltese et al., 2018)
- It values problem-solving and troubleshooting as parts of the learning process (Maker Education Initiative, 2019; Bevan et al., 2018).

There may be cases when the concept of 'making' is employed in educational settings that may not necessarily be Maker Education. Consider the following example:

> An instructor gives students a kit with instructions detailing the assembly process. The kit has a predefined outcome. Students complete the project alone, and the instructor assesses their performance based on how well they completed the kit.

This project *does* align with Maker Education in a few aspects. Namely, it involves making, and even kits can provide opportunities for problem-solving and troubleshooting. However, using a kit limits student agency and choice, the activity offers little room for social interaction or teamwork, and the activity doesn't allow for feedback and iteration, which violates Maker Education's emphasis on the design process. The activity would need to instead give the students a choice of materials and avenues to explore with their projects, involve peer interaction and feedback, and focus on assessing the process rather than the end product. Then, the activity could be said to follow the Maker Education approach.

Maker Education also comes with some inherent challenges. It focuses on the process of making projects driven by student choice and agency. This means that learning is extremely individualized. How then can student learning be measured and assessed? Murai et al.'s (2019) *embedded assessment* provides a possible answer by integrating reflective activities into the making process that may be used to assess learner development. Kim et al. (2020) remark that employing embedded assessment aligns with core maker principles such as agency while "supporting teachers to find the right balance between student-driven and system-driven learning" (p. 1427). Rosenheck et al. (2021) further supported the evidence-based embedded approach for assessing Maker Education, identifying six qualities – alignment, action, specificity, articulation, abstraction, and coherence – which "when present in a set of evidence…can instill confidence before making claims about student learning" (p. 181). These qualities show that Maker Education's effect can be demonstrably measured with sufficient evidence (in the form of reflective artefacts). Still, researchers have also pointed out a "need to continue to investigate the generalizability of both tools and principles in other contexts" (Murai et al., 2020).

One of these new contexts is language teaching and learning. Situating language instruction in the context of solving a real-world problem is by no means a revolutionary concept. It is, in fact, central to several methodologies, including project-based learning (PBL) and task-based learning and teaching (TBLT). PBL has even been used successfully as a structuring methodology for CLIL approaches (Yufrizal, 2021). Valente & Blikstein (2019) defined Maker Education as "a new instantiation of the decades-old project of project-based, constructionist, inquiry-driven learning" (p. 268). Maker Education fits well within this umbrella of approaches to make language and learning real and relevant to learners.

Literature has begun to suggest that Maker Education for language learning can effectively integrate skills, language, and content. Seymour (2018) found that engaging in maker activities was "ideal for the acquisition of conversational and academic vocabulary" (p. 82) because communication is a vital part of the making process. Kannan, Brenneis, and Nader-Esfahani (2021) employed Maker-Centered Learning (Clapp et al., 2016) in a language learning context to guide students in creating resources for their on-campus library and museum, finding that their intervention built critical thinking skills and learner autonomy while improving students' language skills. Alley (2018) used Maker Education to teach an experimental English course in a Mexican Engineering school. He noted that Maker Education closely aligns with a constructivist learning environment, which is "a community of learning that thrives on motivated learners helping each other to solve problems while at the same time interacting with others and solving problems through the use of a target language" (p. 1). Alley concluded that one of the key benefits of the approach was to situate the learners in a *zone of proximal development* (Vygotsky, 1978) wherein "students brought their previous experiences in second language use, and these experiences were immediately and personally put to use in a second language use context" (p. 6). Dubreil & Lord (2021) concur with Alley's conclusions that Maker Education can be effective for language learning, noting Maker Education's ability to situate language where "it is relevant when it is connected to the world around us and [with] real, complex problems" (p. x).

Maker Education is grounded in the physicality of hands-on making, with a focus on learner agency, learning from failure, reflection, and iteration. However, Maker Education faces additional challenges that may prevent its widespread adoption for language learning. First, materials and suitable facilities for making are not typically available in language learning environments. Furthermore, instructors may feel uncomfortable teaching content from the STEM fields. The aforementioned roadblocks to the adoption of Maker Education can only be surmounted with (1) a clear pedagogy grounded in research, (2) a way of integrating Maker Education into existing language learning systems, and (3) professional development for involved stakeholders. If these barriers can be overcome, the approach has the potential to help learners learn language and content while developing a range of skills, such as problem-solving, collaboration, and creativity.

However, the field needs more research on the Maker Education approach in tertiary language learning contexts. Researchers have begun exploring it in language learning, but most current findings are anecdotal or observational. This study aims to fill this gap by investigating the effects of Maker Education in a tertiary CLIL context. The current study will investigate this topic through the following research questions:

1 In a higher education language learning context, does Maker Education offer skill development benefits consistent with those documented in Maker Education literature?

2 Does Maker Education in higher education language learning courses offer any additional benefits?

Method

The researchers designed a study to investigate the effects of a Maker Education intervention in a tertiary CLIL curriculum. The project was conducted at a 4-year foreign language university in Japan. The first step in the research project was recruiting teachers willing to carry out Maker Education activities within their existing language-learning curricula. Volunteer teachers were provided training about the basic tenements of Maker Education and given a list of key components the lessons needed to include to ensure that they fit within the Maker Education approach (Table 1).

Table 1

Key components of our Maker Education approach

Key component	How this looks in the classroom
1. Contextualizes making in the process of solving meaningful problems.	A problem that needs solving is identified before making takes place.
2. Involves hands-on construction of a sharable item.	Students use provided materials to create their projects. They are responsible for making.
3. Gives learners agency in how to complete a project	Students should be able to select materials and tools, then choose the form of their projects.
4. Involves a social component. Sharing, feedback, and collaboration should be a key part of the process.	Students work with their peers, exchanging ideas and giving feedback through the making process.
5. Focuses on the process (not the final product), with failure, feedback, and iteration being key components.	The focus should be on the process of making. It is okay if students are unsuccessful in the end; focus on what they learned as they go through the process.

The instructors and researchers planned lessons and units centered around Maker Education activities. Once an activity was designed, the researchers vetted the lesson plans to ensure compliance with the Maker Education approach and ensure that it integrated well into the existing curricula. These activities were designed to be engaging and motivating while providing an authentic and meaningful language-learning experience (Table 2).

Table 2
Overview of Maker Education activities and their educational contexts

Activity	Description of activity	Example context or topic
1	Disassembly and repair of old electronic devices.	E-waste, sustainability, right-to-repair
2	Creating LED circuits and integrating them into objects.	Electronics, circuit design
3	Creating a system for communicating over long distances.	Communication, signal transmission
4	Creating art using traditional materials to convey a specific memory.	Art, memory, traditional materials
5	Designing a load-bearing tower out of edible items.	Structural engineering, food science
6	Upscaling old clothing into new items.	Sustainability, fashion design
7	Protect a falling object (egg) from an impact.	Physics, material science

The maker education activities were integrated into course content and topics. For example, the electronics disassembly and repair activity was completed after instruction on e-waste, sustainability, and the right-to-repair movement. Each activity followed this basic structure, with at least a class period of instruction on a topic followed by a Maker Education activity in the subsequent class period.

Participants (n = 129) were all majoring in English. All participants were either first or second-year students. The average CEFR level was B2 (TOEIC 505–780/ TOEFL iBT 72–94). Prior to involvement in the project, participants were given an explanation of the study and consent forms per the university's informed consent policies. Participants wrote an open-ended reflection about the experience of creating their project. Writing the reflections took place immediately after completing the maker activity to ensure the experience was fresh in the participants' minds. If participants could not complete the survey in the allotted time, they were permitted to submit it within 24 hours of completing the activity. Reflections from participants who either did not complete the reflection in the time frame or did not give their consent were removed from the study. The survey software, Google Forms, prevented participants from submitting a reflection of less than 150 words to ensure they covered their experiences in enough detail.

Analysis

Once data collection was complete, participant reflections were anonymized by removing personal data and then assigned an alphanumeric code for sorting and identification purposes. MAXQDA 2022 (VERBI Software, 2021) was used to code the reflections. Before coding, a list of priori codes was developed based on literature and previous studies (see Table 3).

Table 3
A Priori codes, sources, and example statements

Code	Designation in literature	Source	Example statement
Bridging knowledge	*Bridging knowledge*	Maker Education Initiative, 2019	I remember what I learned in science class about electricity.
Challenges or failures	*Failure, failing to learn*	Maltese et al., 2018	When we tested our prototype it broke.
Content-area knowledge	*Content knowledge*	Maker Education Initiative, 2019	I could understand the difficulty of making sustainable products by disassembling a phone.
Cooperation and collaboration	*Social scaffolding, social and emotional engagement*	Maker Education Initiative, 2019; Beven et al., 2018	My classmate helped me think of ways to solve the problem.
Problem solving	*Troubleshooting, problem solving*	Maker Education Initiative, 2019; Beven et al., 2018	We tried connecting the circuit in a different way.
Reflection	*Reflection*	Martinez & Stager, 2019, p. 80–81.	Looking back, we should have…because…

The reflections were coded clause by clause. A category of codes was only considered a theme if it appeared in a range of at least 20% of the reflections. The list was expanded during the coding process as new themes emerged from the data. The themes positive experiences, design process, and agency were added in this manner. Additionally, some themes were subdivided into subthemes for more meaningful analysis. Reflection was split into failure-based and success-based to help the researchers know the impetus for reflection. Cooperation and collaboration was split into within-team to indicate they worked with a team member, or external to indicate interaction with a teacher or another classmate. To ensure high reliability, two independent experts coded the data following the coding system. Interrater reliability was carried out and showed high agreement (80%) between the raters. Only when the researchers found an item in a range of at least 15% of the 129 total reflections (20) did they designate it as a theme or subtheme.

Once the reflections were coded, an analysis of thematic relationships was undertaken using the proximity of the codes in each document. The software identified a relationship if the document codes were within a maximum distance of 1 paragraph. Further analysis to find codes that overlapped in the same statements was also conducted.

Results

Code occurrence and range

The data were organized and ordered from most to least frequent in occurrence (see Table 4). The nature of the texts analyzed led to *reflection* (185) being the most prominent theme identified from the data, with the sub-categories of *failure-based* (80) and *success-based* (65) reflection both covering a range of over 40% of the total texts. The second most common was *cooperation and collaboration* (131), the vast majority coded as *within-team* (102). *Bridging knowledge* (114) was the next most frequent, with many participants relating the Maker Education activity to their past experiences, studies, or other content area subjects. Mentions of difficulties, problems, mistakes, or troubles, coded as *challenges or failures*, were next most frequent (110). The next most common was *positive experiences* (93). *Problem-solving* (90) was also prevalent, occurring in a range of 54.3% of all the reflection texts. *Content area knowledge* (70) was also relatively frequent, with mentions of the specific content domain of the task. Comments about following the process of iterative design were assigned to the code *design process* (43). Finally, the least frequent codes were *agency* (27) and *situated language* (23).

Table 4

Code occurrences and range in reflections

Code (Core construct)	Number	Range
Reflection	40 (185 total)	115 (89.0%)
Failure-based	80	61 (47.3%)
Success-based	65	52 (40.3%)
Cooperation and collaboration	7 (131 total)	79 (61.2%)
Within-team	102	69 (53.5%)
External	29	24 (18.6%)
Bridging knowledge	114	80 (62.0%)
Challenges or failures	110	86 (66.7%)
Positive experiences	93	61 (47.3%)
Problem-solving	90	70 (54.2%)
Content area knowledge	70	54 (41.9%)
Design process	43	41 (31.8%)
Agency	27	26 (20.2%)

Theme relationships

Theme relationships were calculated using all the codes - including both core constructs and emergent themes. Relationships were analyzed using code proximity and code overlap. Codes were considered to be in close proximity if they occurred within one paragraph of another code within the same reflection. Code overlaps were counted if the codes appeared in the same segment of the reflection and demonstrated potential correlation (see Figures 2–3).

Figure 2

Code proximity

Code System	Problem-solving	Challenge or failures	Positive exp.	Situated lang.	Reflect.	Success based (sub)	Failure based (sub)	Bridging knowl.	Content knowl.	Design Process	Coop. & Collab.	External (sub)	Within team (sub)	Agency
Problem-solving	0	115	96	20	42	82	75	101	61	63	12	24	93	31
Challenges or failures	115	0	102	30	61	63	109	135	85	60	8	43	111	49
Positive experiences	96	102	0	22	47	71	55	112	73	48	9	31	102	25
Situated language	20	30	22	0	10	17	24	21	21	7	0	7	41	4
Reflection	42	61	47	10	0	14	35	56	31	15	2	13	48	14
Success based	82	63	71	17	14	0	30	65	38	46	10	22	83	15
Failure based	75	109	55	24	35	30	0	100	63	26	10	29	82	29
Bridging knowledge	101	135	112	21	56	65	100	0	109	42	7	25	99	37
Content area knowledge	61	85	73	21	31	38	63	109	0	28	4	10	55	28
Design Process	63	60	48	7	15	46	26	42	28	0	12	8	43	15
Cooperation and collaboration	12	8	9	0	2	10	10	7	4	12	0	6	13	4
External	24	43	31	7	13	22	29	25	10	8	6	0	34	8
Within team	93	111	102	41	48	83	82	99	55	43	13	34	0	30
Agency	31	49	25	4	14	15	29	37	28	15	4	8	30	0
Totals	815	971	793	224	388	556	667	909	606	413	97	260	834	289

Figure 3

Code overlap

Code System	Problem-solving	Challenge or failures	Positive exp.	Situated lang.	Reflect.	Success based (sub)	Failure based (sub)	Bridging knowl.	Content knowl.	Design Process	Coop. & Collab.	External (sub)	Within team (sub)	Agency
Problem-solving	0	16	6	1	1	8	6	2	1	3	0	0	7	3
Challenges or failures	16	0	3	0	1	3	14	1	0	0	0	6	12	4
Positive experiences	6	3	0	3	5	12	5	6	4	0	1	0	18	3
Situated language	1	0	3	0	0	1	2	2	1	0	0	0	7	0
Reflection	1	1	5	0	0	0	1	11	1	1	1	1	4	2
Success based	8	3	12	1	0	0	1	4	1	0	0	0	13	0
Failure based	6	14	5	2	1	1	0	10	3	0	1	6	8	3
Bridging knowledge	2	1	6	2	11	4	10	0	16	1	0	1	4	2
Content area knowledge	1	0	4	1	1	1	3	16	0	1	1	0	1	0
Design Process	3	0	0	0	1	0	0	1	1	0	0	0	2	2
Cooperation and collaboration	0	0	1	0	1	0	1	0	1	0	0	0	0	0
External	0	6	0	0	1	0	6	1	0	0	0	0	3	0
Within team	7	12	18	7	4	13	8	4	1	2	0	3	0	3
Agency	3	4	3	0	2	0	3	2	0	2	0	0	3	0
Totals	54	60	67	17	29	44	61	61	30	10	4	17	83	22

The code *challenges or failures* was most common in the proximity measure, most frequently manifesting in proximity to *bridging knowledge* (135 occurrences), *problem-solving* (115), *failure-based reflection* (102), and *positive experiences* (102). By proximity, *challenges or failures* manifested near *problem-solving* (115), *positive experiences* (102), *failure-based reflection* (109), *bridging knowledge* (135), and *within-team cooperation and collaboration* (111). Overlaps, meaning the theme was mentioned in the same utterance, were most frequent with *problem-solving* (16), *failure-based reflection* (14), and *within-team cooperation and collaboration* (18).

Within-team cooperation and collaboration was also found in proximity with *positive experiences* (102), *bridging knowledge* (99), and *problem-solving* (93). Additionally, *within-team cooperation and collaboration* overlapped with *positive experiences* (18) and *success-based reflection* (13). *Bridging knowledge* and *content-area knowledge* were also found in close proximity frequently (109) as well as overlapping (16).

Discussion

Benefit alignment with Maker Education literature

The study's first research question was, "In a higher education language learning context, does Maker Education offer benefits consistent with those documented in Maker Education literature?" Participant reflections showed evidence of reflecting on their work, cooperating and collaborating, bridging knowledge to and from other disciplines or experience, utilizing problem-solving skills, navigating an interactive design process, and exercising agency. These skills all align with constructs and skills identified in Maker Education frameworks (Maker Education Initiative, 2019; Bevan et al., 2018; Cohen et al., 2017). However, in the context of this study, the strength of evidence for the skills used by the participants varied.

One particular standout construct the data highlighted was the importance of challenges or failures as crucial to the learning process, aligning well with Maltese et al. (2018) research. Though the code *challenges or failures* was not the most common code by frequency, it did occur in the greatest range of documents (66.7%), second only to reflection, which was a given, as data were extracted from reflections. The data strongly emphasized the importance of *challenges and failures* as central parts of learning through the making process. Some representative segments included, "I attached the battery and the LED light. However, the LED light didn't light up because I didn't cut the copper tape" or "the first thing that I got confused about was the size of the screws. There were many types of screwdrivers and it was very difficult to find the one that suited every screw". The data showed that this construct was aligned and closely related to several other codes, emphasizing its role as a nexus for actualizing many other essential skills (Maltese et al., 2018). A core strength of the Maker Education model is its focus on iteration, which inherently is informed by failure and difficulty. In the data, challenges or problems were often the catalyst that led to failure-based reflection, problem-solving, critical thinking, collaboration, or bridging knowledge from other disciplines. This aligns well with social constructivist theory (Vygotsky, 1978), which posits that learner development occurs at a point beyond the learner's ability, where schema and input must be reconciled and used to construct knowledge that allows learners to deal with problems outside the purview of their current capabilities.

Cooperation and collaboration was an important component of many of the reflections (61.4%). Well-designed Maker Education activities should provide sufficient challenge to push learners into the zone of proximal development (Vygotsky, 1978), wherein external guidance from peers or experts becomes essential to learning. A participant remarked, "To be honest, I'm not very handy, so this task was very challenging for me. However, with the help of the partner and the photos, we were able to accomplish it." This idea of the enabling power of cooperation was echoed by many participants when faced with a challenge or difficult task. In addition, a core practice of makerspaces and Maker Education is sharing created artifacts, which is a motivating element throughout the process itself. Learners may experience strong intrinsic motivation to share their creations and will seek the best avenues for explaining their creations to others.

Maker Education themes with limited evidence

The least frequent themes found in the reflections were *agency* and *design process*. However, both themes were found in a range of more than 20% of the total documents. *Agency*, the code referring to participants' agency to pursue their goals on their own initiative, was difficult to identify conclusively from the reflections. While more participants may indeed have exercised agency in completing the activities, the two coders had difficulty finding overt examples to clearly code as *agency*. Occasionally, there were statements directly using "I choose" or "we selected", but these occurrences were relatively sparse. It may also be the case that the reflection used to gather data was not an appropriate method of looking for examples of agency.

Another Maker Education principle, design process, was also challenging to code, but more importantly, the researchers did not find overt references in the data over the range of maker activities. Maker Ed (2019) identified *design process* as one of their Maker Elements, defining it as "a way to approach challenges by brainstorming, prototyping, testing, and iterating" (Maker Education Initiative). The degree to which the iterative cycle is applied varies depending on the activity type, and specific activities, such as the electronics disassembly activity, are difficult to fit within this framework even though they are quintessentially Maker Education activities (Hughes & Kumpulainen, 2021). It is possible that more evidence for the design process could be easily collected using embedded assessment throughout the process of making, instead of at the end of the making activity as was done for this study.

Additional learning benefits of Maker Education

The second research question, "Does Maker Education in higher education language learning courses offer any additional benefits?" looks into other possible affordances of Maker Education when applied in higher education language learning contexts.

First, the data also indicated that the Maker Education activities were positive, motivating experiences for the participants. *Positive experiences* were surprisingly common in passages containing *challenges and failures* (102 instances of code proximity). Though not all participants were successful in overcoming their challenges, this indicates that challenges motivate and have a positive effect on learning. However, in the current study, the prevalence of this code may have been due to the novelty of hands-on activities. One participant remarked on the uniqueness of the experience in this way, “I usually have a lot of discussions in class, but I think I enjoyed it more by using my body as well as my head.” The overall positive attitudes of participants may also be connected with so-called “light-bulb moments” (Chand & Gross, 2021) that trigger a positive emotional response as knowledge and experience merge into conceptual understanding. Longitudinal interventions may be necessary for educators to gauge whether positivity is sustained following repeated exposure to Maker Education curricula.

Finally, the reflections showed that the maker education interventions were valuable ways of getting the participants to apply a wide range of content knowledge from various subjects and their personal experiences. Examples of *bridging knowledge,* connecting the activities to other subjects or past experiences, were widespread in participant reflections. As the activities themselves were slightly unusual for tertiary-level social sciences curricula, participants frequently connected their experiences to schemata from their primary and secondary education and everyday experiences. Depending on the activity, participants drew parallels to subjects they learned in the past or were currently studying. This illustrates the potential for Maker Education to meaningfully integrate content and subject areas into language education in a way that does not discount or artificially compartmentalize knowledge from other disciplines.

Limitations

The current study took place at a private 4-year language university in Japan. Therefore, the results may not be applicable in other contexts where students’ language backgrounds or learning histories differ. Furthermore, in the university where the study took place, reflection is a prominent component of the curriculum, with reflective activities integrated into the curricula of the majority of classes. This means that students receive practical instruction and the opportunity to reflect frequently on their educational experience. As the data gathered for this study were from reflections, this could potentially mean that participant language is atypical for this particular context. Therefore, the reflections may have been considered a natural or logical step following the Maker Education activities. In contexts where reflection is less integrated, explicit instruction and practice may be necessary to familiarize students with how to write reflections.

Furthermore, the instructors of the classes themselves may have influenced the results. Instructors who volunteered to participate in the study may have introduced self-selection bias into the data. Therefore, the participating instructors are likely not representative of typical tertiary language educators. They may have been at the more creative, willing to experiment with alternative methodologies end of the spectrum. More data is needed from different instructors in different contexts to ascertain if this is the case. If researchers implemented a similar study on a departmental level in different contexts, the data might be affected by a more generalized sample of instructors. Additionally, more data must be gathered from a greater variety of Maker Education interventions.

Conclusion

Even in language learning contexts, the current study provides evidence that Maker Education activities, if carefully and principally implemented, can support vital skills acquisition for language learners. Considering the pressure on educators to offer added value beyond content and language, Maker Education is a possible solution. However, some hurdles need to be overcome if Maker Education is to be more widely adopted for language learning. First, teacher development is key to helping educators understand how to implement Maker Education into their courses effectively. Second, materials and appropriate facilities can pose a potential roadblock to adoption, as getting started can seem intimidating when comparing one's context to well-funded institutions with established makerspaces. The needs of Maker Education can be fulfilled using donated or recycled materials rather than being contingent on specialized materials or a dedicated environment. The ethos of making has always been rooted in sustainable and democratized practice, regardless of whether makers use the latest fabrication technologies or simple materials like cardboard and glue.

While Maker Education can be used at scale to underpin institutional curricula, it is perhaps most practical and likely to be adopted when slotted into existing models. Thereby integrated, it can offer additional benefits that may have been difficult to provide within the scope of an institution's existing methodology. In the case of this study, Maker Education did not replace the current CLIL model; rather, it augmented it by allowing students to engage with content intellectually and linguistically through a making process. Dubreil and Lord (2018) note that making-infused learning is "especially relevant" in CALL approaches due to its origins in the STEM subjects and the use of technologies in the making process (p. ii). This approach provides an engaging means of interacting with content though language that is immediately needed and relevant. Higher education language instructors should consider adding Maker Education to their pedagogical toolbox. The approach creates suitable conditions for tying content, technology, and language together in meaningful contexts. In a world where language skills alone are insufficient and holistic learner development is expected, the authors posit that Maker Education is an appropriate solution for language learning teaching and learning in the 21st century.

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