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Integrating the Maker pedagogical approach in teacher training: the acceptance level and motivational attitudes

Amaia Quintana-Ordorika[1] · Edorta Camino-Esturo[2] · Javier Portillo-Berasaluce[1] · Urtza Garay-Ruiz[1]

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Abstract

In recent years, Maker Education has gained popularity in formal education, but the perceptions of pre-service teachers after participating in a maker training program at a university-based makerspace remain to be explored. The purpose of this study is to analyze the acceptance level and the degree of motivation of pre-service teachers towards the maker educational approach. The research assesses attention, relevance, confidence and satisfaction according to Keller's motivational model, as well as the acceptance of the maker approach using the Technology Acceptance Model (TAM). The study focuses on Early Childhood Education pre-service teachers from UPV/EHU (University of the Basque Country) who have been involved in designing teaching and learning plans based on Maker Education. The results show a strong motivation among the pre-service teachers in terms of attention, relevance, confidence and satisfaction towards the maker approach. The study also highlights a high level of technology acceptance. These findings underline the positive impact of maker-based learning methods and suggest that greater motivation correlates with the positive attitudes towards integrating this pedagogy in the future. In light of these findings, integrating innovative maker pedagogy into teacher training appears to be beneficial, as the high levels of acceptance and motivation indicate its potential to equip students with essential twenty-first century skills.

Keywords Maker pedagogical approach · Motivation · Technology acceptance · Teacher training · Early childhood education

✉ Amaia Quintana-Ordorika
amaia.quintana@ehu.eus

1 Department of Didactics and School Organization, University of the Basque Country (UPV/EHU), Leioa, Spain

2 Department of Educational Sciences, University of the Basque Country (UPV/EHU), Leioa, Spain

1 Introduction

Over the past few years, the maker pedagogical approach has gained prominence in the promotion of creativity, innovation, and entrepreneurship (Jin et al., 2021; Wang & Shan, 2019). It has not only changed and empowered society in general but has also enriched and modified educational environments for its potential to foster experimentation, design, and creation with physical, digital or combination of both physical and digital materials (Godhe et al., 2019). The research about making in formal education is growing (Hughes et al., 2022), yet there is a scarcity of empirical research on how early childhood pre-service teachers perceive this approach in relation to their motivation and acceptance of technology. Nonetheless, there is still limited research on how future educators view the level of acceptance and motivational effects of this approach. Therefore, the purpose of this article is to increase understanding of how trainee teachers view hands-on learning. This will be accomplished by exploring their perceptions after receiving theoretical training and participating in the design and creation of teaching and learning plans centered around maker activities.

1.1 The maker movement in education

The word maker education unites both terms "maker" and "education"; maker literacy is the expression of ability. A makerspace would be a physical space where makers work collaboratively, share knowledge and ideas, and thoughts by using methods such as analysing and problem-solving (Gantert et al., 2022).

Maker education has the potential to transform educational practice by encouraging collaboration and experimentation, critical thinking and initiative (Blikstein, 2013; Martinez & Stager, 2013; Peppler et al., 2016). Moreover, it enables learners become active problem-solvers (Halverson and Sheridan, 2014; Kurti et al., 2014; Martinez & Stager, 2013) and members of the teaching and learning process (Chu et al., 2017; Hira & Hynes, 2018). Compared to traditional teaching methods, maker education focuses on projects that promote collaborative teamwork, allowing students to engage more deeply in their learning (Godhe et al., 2019). It also gives students the opportunity to learn topics that are more relevant for them (Blikstein & Worsley, 2016).

Maker educational institutions, integrate ICT and teaching practices based on the usage of technological tools, and an internet-based environment (Yang, 2020). Technical technologies such as robots, electronics or 3D printers are more popular and accessible than ever (Tan, 2019). The same author considers maker education as an approach that cultivates a maker spirit among learners, fosters continuous development, and embodies inquiry learning and underlines the importance of innovation ability and entrepreneurship awareness. Integrating technology into the design and creation of artefacts plays a crucial role in enhancing the learning experience. When students use technology to create these artefacts, they are actively participating in a learning process that has the potential for lasting the educational impact. Maker education promotes the development of artefact design and creation, a concept first introduced by Papert (1986). By facilitating the development of objects aligned with learners' interests and involving them in the exploration and construction of objects, a deeper acquisition of knowledge is achieved.

1.2 Makerspaces in higher education

The main goal of a university makerspace is to bring students together in a space suitably designed to give them the opportunity to collaborate and solve challenges that are of interest to them (Hynes & Hynes, 2018). As this is the case, it opens a new door for the inclusion of other disciplines and the tools, gadgets and resources provided in this space give students an excellent opportunity to prototype and build their ideas, (Wong & Partridge, 2016). Making allows students to engage with topics that are personally relevant and meaningful, and the sense of agency they gain needs to be emphasized (Jones et al., 2020). There is also a shift in the usual roles of teacher and learner. The learner would be at the center, and the teacher would take on the role of a guide and supportive facilitator (Harron & Hughes, 2018). Technology will be the main goal of the space, allowing students to develop their technological skills; collaboration happens when researchers, innovators, and agents work together and share ideas; it would be a student-centered place and the maker mindset with an entrepreneurial focus are needed. Pettersen et al. (2019) found that most higher education makerspaces have an entrepreneurial focus. The 'focus' varies from university to university. "While the focus is often on technology, makerspaces generally focus on creation" (Slatter & Howard, 2013, p. 273). Working in a makerspace scenario encourages the exploration of innovative ways of teaching and learning processes, and learners gain skills by experimenting and playing with and through technology (Hughes & Morrison, 2020). Technology and active methodologies are the core elements of makerspaces, but having an emotional synergy to overcome obstacles and foster deep learning is also essential (Tesconi, 2018).

1.3 Maker education and teaching

When we talk about maker education, we can see that there are tensions between the different research that has been done. Some of these tensions are linked to the goals of including makerspaces in educational institutions, mentioning that makerspaces objectives and the goals of schools sometimes go in different directions (Godhe et al., 2019). While typical formal school activities tend to focus on learning content knowledge, maker activities focus mainly on learning new skills, collaboration, sharing and creating (Godhe et al., 2019). Some researchers worry that if makerspaces are brought into schools, might lose some of the things that make them special, such as creativity and innovation (Halverson & Sheridan, 2014). There is also concern that focusing too much on the tools in makerspaces might ignore their unique atmosphere and ways of thinking (Martin, 2015). In terms of promoting equity in education, maker learning has a democratizing effect, and maker activities have the potential to impact interest and participation among learners (Barton et al., 2017). Oliver (2016) believes that a supportive network is needed to provide teachers with the necessary expertise to incorporate maker-equitable practices.

Several other studies underline the benefits of applying making in education; Näykki et al. (2019) in their research conclude that the application of making in education through digital systems and tools can provide multiple opportunities for affective learning such as expressing emotions. Papavlasopoulou et al. (2017), have researched that maker activities help develop certain notions such as personal agency, self-esteem, and self-efficacy.

Other tensions concern teaching, specifically how teachers should be trained for formal maker education and what kind of expertise they should possess (Rouse & Rouse, 2022). Previous studies of pre-service teachers based on maker education have shown that participation in a maker program helps to increase participants' maker skills and technological knowledge, especially when it comes to understanding how to choose the right technologies for specific goals (Jones et al., 2020; Stevenson et al., 2019). Heredia and Fisher (2022) concluded in their research that a university-based makerspace program for pre-service teachers focused on learning the tools and technologies helped increase participants' confidence in maker technologies.

Some researchers have also found that dealing with curricular constraints is a challenge when teaching preservice teachers about making education (Rodriguez et al., 2018). Learning from mistakes and making improvements during the design process are important aspects of making education, as highlighted by Shively et al., (2021a, 2021b).

There is also a need for further research into what makes a makerspace teacher fit for purpose, what that teaching should look like, and how ongoing professional development programmes should be developed to support pre-service and in-service teachers (Jones et al., 2020).

It is widely acknowledged that making can have a transformative effect on educational practices, but this is only feasible if teaching practices align with its philosophy and constructionist view (Tesconi, 2018). Blikstein (2013) stresses the importance of creating learning environments that are reflective, experience-based, tailored to the students' needs, and centred around the creation of meaningful artifacts. He also emphasizes the importance of integrating digital tools of open access and maker practices into these learning environments. There are several aspects that can motivate a student to learn and apply knowledge; when a task is interesting and enjoyable (Nikou & Economides, 2018), and when a learner feels satisfied, the student's attitude and engagement are improved (Nikou, 2023). Engagement is a consequence of motivation (Boekaerts, 2016). There are many studies on motivation that emphasize that students are engaged and learning mainly because they find it interesting and enjoyable (Uysal, 2018). Davis (1989) highlighted the idea that motivation affects the acceptance of technology by users. Aligning these previous ideas into the design of the curriculum is essential to obtain the general acceptance of the instructors (Chu et al., 2016).

1.4 Maker education and design principles

The constructionist approach to learning is one of the most common features of maker education, where designing, building, tinkering, and inventing are ways of knowing and learning rather than ways of transmitting knowledge. Interdisciplinary problem solving, openness to sharing knowledge and ideas, experimentation with different tools, materials, and gadgets, and, above all, the development of further reflection and interaction with others are central (Koole et al., 2016).

The word design method was first introduced by Bobbitt (1918) and later popularized by Tyler (1949). A decade later, Bloom (1956) introduced the design principles to classify educational goals and their development. Nowadays, there is a growing interest in the concept of educational design thinking along with human-centered design, which is rapidly gaining popularity and territory around in the world (Brown, 2008; IDEO, 2012). Blakemore (2018) emphasizes that the maker movement is closely related to design thinking, based on the idea that learners learn more when they are truly engaged in designing what is important to them and when they build real-world objects or artifacts.

Simon (2019) believes that educators should engage deeply in design to make things better for themselves and those nearby. More human-centered design approaches are needed to "make, unmake, and remake curriculum in the classroom" (Quinn et al., 2018, p.6). Teachers need to feel empowered to take agency over teaching and learning practice, they should take on the role of "shapers, facilitators and well-informed critics" (Little, 1993, p. 130), they need to position themselves as active agents of their educational and professional development (Buxton et al., 2015; Calvert, 2016). In our research, the main strategy used by the learners was the active methodology, with an emphasis on design thinking (González-Patiño, 2017). This methodological strategy is an approach inspired by the way designers act to solve problems.

As noted in the previous sections, research on making in formal education is growing, particularly in the area of teacher training and professional development. Therefore, there is a need to see what level of motivation is evoked by maker-based approaches, and what is the level of technology acceptance, in order to consider the implementation of maker education in teacher training and professional development programs.

In this particular study, we explored pre-service teachers' perceptions of motivation and technology acceptance after designing appropriate maker-based teaching and learning plans in a university makerspace as a learning environment. In particular, we focus on the early childhood education level and emphasize that the principles of makerspaces fit well with the philosophy and practices of early childhood education, as research has shown that they are also appropriate in kindergartens (Marsh et al., 2019).

2 Research Questions

The framework described above was used to understand what is the current situation of maker education in formal education. In this paper, we analyze the motivation and technology acceptance level of early childhood pre-service teachers towards maker education after participating in an apprentice maker program at a university makerspace and after designing maker-based teaching and learning plans. For this purpose, the following research questions were formulated:

RQ1: How do pre-service teachers perceive their level of motivation in terms of attention, relevance, confidence, and satisfaction towards maker education?
RQ2: What level of acceptance do pre-service teachers have towards maker education in terms of usefulness, ease of use, enjoyment, and intention to use?
RQ3: Does the general acceptance level influence the motivation level?

3 Method and Procedure

3.1 Participants and context

The participants were students ($N=38$) at the Faculty of Education of the University of the Basque Country, studying for a degree in Early Childhood Education Teacher Training. The participants, who were following the subject of Information and Communication Technologies (ICT) in the second course of the degree, chose to answer the questionnaire anonymously after completing the subject at the end of the autumn term 2022. The participants were given a QR code on the last day of the course and they freely decided to answer it. All the participants who attended the training answered the questionnaire. The sample was chosen by means of non-parametric convenience sampling (Rossing et al., 2012) which is in fact the total number of students enrolled in the trilingual (Basque, Spanish and English) Early Childhood Education course. They are the ones who received both theoretical and practical training in Maker Education and who designed the teaching and learning plans.

The context of the study is a makerspace in our faculty. It is a pioneer in the university context in Spain. The makerspace offers digital fabrication facilities such as 3D printers, a laser cutter, and a range of tools and materials, as well as robotics kits. In the makerspace, participants have the opportunity to design and manufacture, prototype with electronics, learn programming, including basic programming of embedded systems, and use the tools and gadgets available.

Pre-service teachers, were trained in the maker pedagogical approach, both theoretically and in terms of maker principles, skills and technologies. They then designed maker-based teaching and learning plans in the makerspace, which is considered an innovative and technological learning space where collaboration and new learning dynamics are used to carry out collective projects (Pettersen et al., 2019). They implemented a number of proposals based on constructivism: hands-on learning through building things. These teaching and learning plans are innovative learning units developed in our faculty's makerspace 'Innovative Learning Environment'. The training lasted one semester and was delivered through a website platform that included an introduction to maker education, a guide to the general aspects of working on projects, planning, design and evaluation of maker activities. With regard to the maker tools and technologies available in the makerspace, the trainee teachers explored and became familiar with the possibilities of each of the tools and materials.

The careful planning of the teaching–learning processes target Early Childhood students and are based on the promotion and encouragement of active learning (Talbert & Mor-Avi, 2019). Pedagogically, the aim is to achieve the best learning outcomes that enable students to acquire twenty-first century skills: student-centred learning, solving real-world challenges and problems, receiving accurate feedback and assessment, and incorporating higher-order thinking skills such as analysis, synthesis and evaluation (Mahat et al., 2018). The main outline of the proposed educational plans has been based on the process of gathering all the participants, students and teachers, in a physical space that has been especially designed for the construction of artefacts; a makerspace. The collaborative experience of designing has been aimed towards a common goal: becoming an expert in a particular category such as robots, kits for real world interaction, coding… designing accordingly a suitable teaching and learning plan and finally sharing the project with the rest of the classmates. When working together on a shared task, individual and collective efficacy is strengthened (Pieters et al., 2019).

This study was conducted in the project investigating how the maker pedagogical approach could be integrated into the Information and Communication Technologies (ICT) subject. The biggest challenge for a teacher would be to design teaching and learning processes with a special focus on designing engaging classroom experiences based on maker methodology that supports academic learning (the curriculum) as well as a range of other key 21st-century skills. Key skills, elements and characteristics of makerspace (Becker & Lock, 2021) that meet the goals of the design process based on the 4Cs (critical thinking, creativity, collaboration and communication).

Currently, future Early Childhood teachers need to know which are the key competences defined by the Spanish national curricula (LOMLOE 2020) in its three dimensions (*knowing, knowing how to do and knowing how to be*) at all levels and stages. They must become experts in how to develop an effective set of strategies to work the competences through the LOMLOE and the parameters of constructivism. Transversality through the Sustainable Development Goals of the 2030 Agenda, cooperative work, culture of thinking, sensitivity to a sustainable world, reflection, respect, tolerance, motivation, entrepreneurship, creativity and other strategies and values developed through active methodologies in the classroom. The development of Digital Competence in Early childhood education is one of the key competences in the curriculum and Sanchez Vera (2021) reassures that students at this stage also need to be digitally literate. It is believed that the competences set out in the national Spanish curricula can be easily translated into desired learning outcomes that can be achieved through different forms of makerspace learning. Through the proposed design plans, future educators have been taught to integrate making activities into the early childhood stage, with the aim of ensuring the full inclusion of students in the digital society, following one of the objectives of the Spanish education system (LOMLOE, 2020, *article 2*).

For the scope of this paper, we focus on early childhood trainee teachers who played an active role in designing appropriate teaching and learning plans based on an adapted version of the proposal of the Massachusetts Institute Technology (MIT) 'Maker' methodology and Van den Akker's (2013) approach to the elements of the curriculum. The projects that the trainee teachers had to design had to cover several aspects, including the general characteristics of design mentioned by Van den Akker (2013) to approach the curriculum. In this model, all curriculum components are included in a spider web, such as the aim and objectives, materials and resources, timing… Each of the curriculum components are an important part of a strong network (Becker & Jacobsen, 2020). We have based our proposal on some of these components, but we have made some modifications to adapt it to our teaching and learning scenario. In the following Fig. 1 we provide a draft that the training teachers have used to design their teaching and learning plans.

3.2 Instrument

In this paper two different instruments have been used to elaborate the questionnaire, on the one hand, the Reduced version of The Instructional Materials Motivation Survey (RIMMS), and on the other hand the Technology Acceptance Model (TAM).

4 RIMMS

4.1 ARCS Model of motivational Design

The ARCS model of motivational design created by John Keller, "the ARCS model", has been used many times in the field of educational science to test the effects of instructional materials (Keller, 1983, 1999, 2010; Keller and Kopp, 1987). It consists of four subscales based on the following foundations and principles: attention, relevance, confidence, and satisfaction (Keller, 2010, p.44). Keller believes that when the first three motivational principles (attention, relevance, and confidence) are achieved, people are ultimately motivated to learn. The feeling of satisfaction with the process or outcome of the learning experience (the satisfaction principle) is necessary to have the desire to continue learning. Keller (2010) believes that "each of the four subscales can be used and scored independently" (p.282). According to the selected ARCS model (Keller, 2015) there must be an appropriate balance between the four categories to achieve motivation.

In our research, the Reduced version of The Instructional Materials Motivation Survey RIMMS has been used (Table 1). Loorbach et al. (2015) conducted a study in a self-directed learning environment and concluded that a reduced version of IMMS, called RIMMS (Reduced Instructional Materials Motivation Survey) fitted the four factors of the ARCS model with an instrument that consisted of 12 items.

Title: name of the project
General topic

General description
Final product:
Implied area/areas:
Timing:
LEARNING SCENARIO+ define the learning space

Skills
Specific competences (*what I want them to train or practice ..)*
Together we will learn to…

- *To create a…*
- *To increase awareness…*

Objectives (*what I want them to understand, learn, know…)*

Teacher preparation/Student preparation (readiness to use the resources, gathering and collecting the accounts, tool skills…?)
Resources needed (**academic** "readings, videos, texts…"; **maker** "makerspace time, tools, materials, applications)

Learning activities TASKS
Divided into the following stages: In each task: Skills + objectives + EVIDENCES

1. Initial challenge *(establishing bridges between what they know with the new learning scenario).*
    - *Did you know that…?*
    - *What do you know about…?*
    - RESEARCH
2. Working teams (*groupings). *Initial brainstorming + WONDER phase
3. Design tasks (*involving higher order thinking*)
    - IMAGINE (create a first draft) *Use cooperative learning techniques to complete it (involving all the group members)*
    - DRAW+ design + prototype + THINK ABOUT THE MATERIALS! (Which materials could be replaced so as to be as sustainable as possible?)
    - EXPLORE + RESEARCH+ Reflect
    - Redesign + connect (test hypotheses, connect concepts, find connections "what worked/didn´t work) The teacher provides feedback
    - APPLY +BUILD IT(*how are you going to document the process?)*

Reflection and assessment
-How are students going to reflect on their practice? Self-assessment? Peer-assessment?
-**Which are the "pieces of evidence" that are going to be evaluated and how?**
Portfolios, blogs, journals, assemblies, quizzes, tests, reports, surveys, photo-diaries

Sharing ways.

Teaching and learning plan template, based on the curriculum elements proposal of Van den Akker, (2013) and the "Maker methodology" by MIT (Massachusetts Institute Technology. http://k12maker.mit.edu/plan).

Fig. 1 Teaching and learning plan design template. Teaching and learning plan template, based on the curriculum elements proposal of Van den Akker, (2013) and the "Maker methodology" by MIT (Massachusetts Institute Technology. http://k12maker.mit.edu/plan)

5 TAM

5.1 Technology acceptance model

To analyse the degree of acceptance of the maker methodological approach in this study, we have used the "Technology Acceptance Model" (TAM) (Davis, 1989). This model is suitable to explain perceptions about the usefulness (PU), ease of use (PEU), attitude towards its use (ACU), enjoyment level (PEN) and intention to use it (IU). Following research in education, the TAM model and its various

Table 1 Reduced Instructional Materials Motivation Survey (RIMMS) items

Subscales	items		
Attention	A3. Quality of the sessions	A6. Suitability of the arrangement of assignments	A10. Variety of assignments, illustrations, etc
Relevance	R1. Content and materials are related to previous knowledge	R6. Content is worthy, purposeful, and advantageous	R9. Usefulness
Confidence	C5. Confidence to learn the content	C7. Confidence level to succeed in an assessment or evaluation	C9. The good organization of the tasks
Satisfaction	S2. Willingness to know more about it	S3. Enjoyment level of having taken part in the project	S6. Feeling pleasure to have taken part in well-designed tasks

versions have been widely used in education as a credible model for evaluating different learning technologies (Granić & Marangunić, 2019).

In the model proposed by Davis (1989) Fig. 2, variables such as the perceived usefulness (PU) and perceived ease of use (PEU), are the ones that will be the most critical and will consequently be linked to the attitude towards its use (ACU), the enjoyment (PEN), and lastly intention to use it (IU).

Based on the model proposed by Davis and taking into account the 5 dimensions, an adapted questionnaire and variables have been used to predict the degree of acceptance of the methodological approach (Table 2):

- Perceived usefulness (PU): It makes reference to the degree to which a student (user) believes that using the maker pedagogical approach would enhance his/her job performance.
- Perceived ease of use (PEU): the student's (user´s) belief about the degree of difficulty that using the maker methodological approach has.
- Perceived enjoyment (PEN): The student's (user´s) belief about the degree of enjoyment of using the maker pedagogical approach
- Attitude towards use (ACU): The student's (user´s) perception about the desirability of using the methodological approach
- Intention to use (IU): The student´s (user's) desire level to use the maker pedagogical approach in the future.

5.2 Data analysis

The analysis of the data collected in both instruments (TAM and RIMMS) was carried out using the SPSS statistical program. The initial database has been revised to correct possible errors or duplications in the responses of the teachers-in-training surveyed. The items of each instrument have been recalculated and transformed into new variables corresponding to the subscales relevant to each instrument (RIMMS and TAM). In turn, the global value has been measured in order to establish correlations between both instruments.

In this sense, a descriptive analysis of each instrument has been carried out, both at the subscale level and at the global level, establishing typologies according to the levels of response offered by the teachers in training. A series of categories

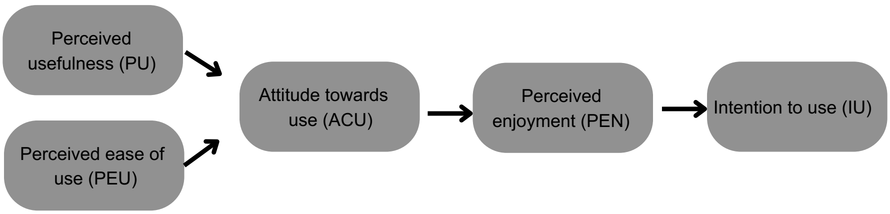

Fig. 2 Technology acceptance model Davis (1989) in Llorente-Cejudo et al., (2022)

Table 2 Questionnaire items TAM

Subscales	items		
PU Perceived usefulness	PU1. Learning improvement	PU2. Eases the general understanding of certain concepts	PU3. Usefulness
	PU4. Enhances the learning		
PEU Perceived ease of use	PEU1. Easy to use	PEU2. Learning and dealing with it has not been a problem	PEU3. Learning and dealing are clear and understandable
PEN Perceived enjoyment	PEN1. Using it is enjoyable	PEN2. I enjoy using it	PEN3. It allows learning by doing
ACU Attitude	ACU1. Learning is more interesting	ACU2. It is a good idea to use it in class	
IU Intention to use	IU1. Use it in the future	IU2. Use it to learn new topics	

established by means of their score values have been elaborated. In both instruments, respondents' scores have been categorized as follows:

- Very Low: scores between 1 and 1.99.
- Low: scores between 2 and 2.99
- Medium: scores between 3 and 3,99
- High: scores between 4 and 4.99
- Very High: scores between 5 and 6.

Subsequently, the percentages of the sample were calculated for each level and, in turn, a descriptive analysis was carried out, which made it possible to calculate statistics with which to extract results to understand and, in turn, answer the research questions developed.

Finally, in order to find statistical evidence to confirm or reject the hypothesis of a significant relationship between the two instruments, a Pearson correlation index was calculated and a linear regression analysis was performed between the two instrumental measurements.

6 Results

The reliability of the instruments used (TAM and RIMMS) was done by calculating Cronbach's Alpha (Table 3). In this sense, both the overall internal consistency of the two instruments and the corresponding subscales have yielded very high coefficients, so we can confirm that there is a high correlation in the variability of the items used and the overall variability of both instruments (Table 3). Likewise, a confirmatory factor analysis was carried out to determine the validity of both instruments, through the Extraction Method, according to its Principal Component Analysis,

Table 3 Results of Reliability and Normality

	Cronbach's Alpha	N of Items	Shapiro–Wilk Test	
			Statistic ($n = 38$)	Sig
Attention	0.896	3	0.919	0.009**
Relevance	0.918	3	0.944	0.055
Confidence	0.894	3	0.953	0.109
Satisfaction	0.967	3	0.972	0.446
RIMMS	**0.971**	**12**	**0.956**	**0.140**
PU	0.949	4	0.960	0.185
PEU	0.872	3	0.928	0.017*
PEN	0.954	3	0.969	0.355
ACU	0.903	2	0.949	0.081
IU	0.934	2	0.952	0.105
TAM	**0.976**	**15**	**0.955**	**0.130**

*$p < .05$, **$p < .01$

without finding any evidence contrary to the appropriateness of the items and subscales to the original order established in the bibliography. On the other hand, the normality of the subscales and of the instruments, calculated by means of the Shapiro–Wilk test ($n < 50$), has been checked, obtaining diverse results, although, with two exceptions (Attention and PEU), they follow a normal distribution.

7 Pre-service teachers perceived motivation level

Through the RIMMS instrument analyzed, we can extract the perceptions of the sample used on the level of motivation towards the maker methodology. The scores obtained were classified into 5 levels of perception (Table 4), in a sequence of ordinal intervals, categorized by their degree of score: very low (1–1.9 points), low (2–2.9 points), medium (3–3.9 points), high (4–4.9 points) and very high (5–6 points).

The percentages of each level of motivation and the statistics used differ according to the subscale. In the case of Attention, the range between the lowest and highest value is 3.33 points. Thus, we can observe that it is the subscale with the least dispersion. The mean is (3.70) and the most repeated value is the one associated with the High perception (50%). It is observed that the responses for this item are less dispersed than the rest, since the range obtained was (3.33) and this implies that the maximum (6) and minimum (1) degree of agreement with the question posed has been indicated.

We can consider this subscale as the least dispersed, although two differentiated and distanced groups can be observed with respect to their perception. On the one

Table 4 Perception of Motivation Level and Statistics

		Attention % (n)	Relevance % (n)	Confidence % (n)	Satisfaction % (n)	RIMMS % (n)
Perception of Motivation Level	Very Low (1–1.9)	0,00% (0)	2,63% (1)	2,63% (1)	5,26% (2)	5,26% (2)
	Low (2–2.9)	26,32% (10)	15,79% (6)	18,42% (7)	28,95% (11)	13,16% (5)
	Medium (3–3.9)	18,42% (7)	23,68% (9)	18,42% (7)	13,16% (5)	31,58% (12)
	High (4–4.9)	50,00% (19)	44,74% (17)	52,63% (20)	44,74% (17)	42,11% (16)
	Very High (5–6)	5,26% (2)	13,16% (5)	7,89% (3)	7,89% (3)	7,89% (3)
Descriptives	Mean	3.70	3.92	3.88	3.72	3.80
	Median	4.00	4.00	4.00	4.00	3.95
	Std. D	0.92	1.08	1.02	1.21	0.99
	Minimum	2.00	1.33	1.33	1.00	1.42
	Maximum	5.33	5.67	5.67	6.00	5.42
	Range	3.33	4.33	4.33	5.00	4.00

hand, those individuals who are located in a less motivated position with respect to the average, which are located around the -S (2.78) and in the Low level (26.32%). On the other hand, that group of students who are positioned in a higher perception (4.62) and in the High level (50%) in terms of participation in the design process of the maker methodology.

Regarding the Relevance subscale, it presents higher central measures, with a mean of 3.92 and is the best rated dimension. The median corresponds to a High perception (4) and a standard deviation of 1.08. The range between the lowest and highest value is 4 points. There is a higher proportion of students with a Very High perception of the subscale (13.16%), which, added to the High level (44.74%), shows a tendency towards a positive perception of the Relevance subscale in the maker methodology used.

Confidence subscale shows similar scores to the previous ones, with a mean (3.88) and a standard deviation (1.02). The level with the highest score is the one associated with a High perception (52.63%), which also shows a high perception of this dimension towards the methodology used.

In the case of Satisfaction, although the median value (4) reports that around 50% of the subjects perceive the subscale as High, the other 50% are below this perception. The mean is at (3.72) and the most repeated value is the one associated with the High perception. It is observed that the responses for this item are quite dispersed, since the range obtained was (5). In addition, the standard deviation exceeds the value of 1 point (1.21). In other words, the average deviation from the mean (3.72) indicates that the subjects' opinions fall into two clearly differentiated groups. On the one hand, we find a group of subjects (2.51) who are dissatisfied with participation in the maker methodology and, on the other hand, another group of subjects (4.93) who are very satisfied with participation.

Finally, regarding the overall perception of the trainee teachers on their level of motivation when participating in the process of designing teaching and learning plans based on the maker methodology, we can see that there is also some variation in the distribution of the data, with a range of 4 points on the scale. Being the minimum score 1.42 and the maximum 5.42 (scale from 1 to 6). It also presents a certain negative skewness (symmetry) (-0.619). Individuals belonging to the Very Low level account for 5.26% of the sample, with a mean motivation of 1.583 and a standard deviation of 0.23 (2 subjects). Students with Low motivation accounted for 13.16% (5 subjects), with a mean motivation (2.45) and a standard deviation (0.47) higher than the previous level. At the intermediate level, the Medium level, around the sample mean (3.8), accumulates 31.58% of the subjects (12), and, specifically, has a mean (3.54) and a standard deviation (0.25) with very low variability. As for the High Level, it presents 42.11% of the indiviluals in the sample, with 16 students who are highly motivated to participate in the maker methodology process. This student body has a mean, at this High Level, of 4.42 points and a standard deviation of 0.35. And finally, the Very High Level has a mean of 5.30 and a standard deviation of 0.12, with 7.89% of the students who consider the methodology very satisfactory.

Regarding the RIMMS measures, we can see that the sample is normally distributed (S-W sig. $>$ 0.05), with a mean (3.80) within the Medium Level, but close to a High perception and a standard deviation (0.99) that positions the sample divided between two differentiated and, likewise, antagonistic groups. One group that is further away from motivation in a group below the average, with lower scores (2.81) and another group above the average (4.79) and more motivated by the maker methodology. In short, we can say that there is a high motivation for people who participate in the process of designing tasks based on the maker methodology and that there is a higher percentage of people who have felt highly motivated when participating in the process of designing.

8 Level of acceptance of the maker methodology

Regarding the level of acceptance of the maker methodological approach in terms of students' perception, it can be considered that, as in the case of motivation, there are different levels of acceptance. The scale used has been the same as in the previous instrument (Table 5).

We will start the analysis by the reference order of the TAM instrument. Thus, the first subscale of the instrument would be Perceived usefulness (PU), which is normally distributed (S-W sig. > 0.05). This subscale presents a mean (3.84) and a standard deviation (1.04) that shows a slight variability, with a range (4.25) that is positioned between minimum (1.25) and maximum (5.50) values over which the sample is distributed according to the PU. The highest percentage (47.37%) is concentrated in the High level, with 18 individuals. The highest levels High and Very High Level add up to a total percentage of 57.9%, which evidences the high level of acceptance of the usefulness of the methodological approach. However, there is a slight inclination to choose the Low option of the acceptance level

Table 5 Perception of Acceptance Level and Statistics

		Pu % (*n*)	Peu % (*n*)	Pen % (*n*)	Acu % (*n*)	Iu % (*n*)	TAM % (*n*)
Perception of Acceptance Level	Very Low (1–1,9)	2,63% (1)	0,00% (0)	2,63% (1)	2,63% (1)	5,26% (2)	2,63% (1)
	Low (2–2,9)	21,05% (8)	26,32% (10)	23,68% (9)	26,32% (10)	21,05% (8)	23,68% (9)
	Medium (3–3,9)	18,42% (7)	21,05% (8)	10,53% (4)	10,53% (4)	15,79% (6)	21,05% (8)
	High (4–4,9)	47,37% (18)	52,63% (20)	44,74% (17)	44,74% (17)	50,00% (19)	42,11% (16)
	Very High (5–6)	10,53% (4)	0,00% (0)	18,42% (7)	15,79% (6)	7,89% (3)	10,53% (4)
Descriptives	Mean	3,84	3,75	4,00	3,97	3,83	3,88
	Median	4,00	4,00	4,00	4,00	4,00	4,00
	Std. D	1,04	,91	1,20	1,28	1,15	1,04
	Minimum	1,25	2,00	1,00	1,00	1,00	1,25
	Maximum	5,50	5,00	6,00	6,00	6,00	5,53
	Range	4,25	3,00	5,00	5,00	5,00	4,28

(21.05%) with a moderate emphasis. This level of the sample scores with an average of 2.618 and close to the -S (2.8), with which we can assume some differences in the acceptance of the usefulness of the methodology in this group of students with respect to the majority of the pre-service teachers.

Regarding the subscale of Perceived ease of use (PEU), we find an abnormally distributed distribution (S-W sig. < 0.05), which shows, as can be seen from the percentage distribution, that there is an unequal perception regarding the ease of use of the maker methodology. In this sense, 26.32% are located in the Low level, 21.05% in the Medium and, in third place, 52.63% thinks highly that the maker methodology is free of effort. Although most answers are located in the category of High ease of use of the methodology, we cannot ignore the fact that, for the rest of the participants, the methodology has a Low-Medium level of ease of use. However, we can rule out the choice of the two extremes, since no one has chosen those options. This is why the range is lower (3), with minimum (2) and maximum (5) values, and the mean (3.75) is lower than the rest of the subscales.

The Perceived enjoyment subscale (PEN) presents a normal distribution (S-W $p = 0.355$), but some differences are observed in terms of the enjoyment perceived (range = 5). 44.74% of the participants consider the maker methodology as highly enjoyable and 18.42% as Very Highly enjoyable, which leads us to consider that there is a high majority (63.16%) that enjoys the methodology. In this sense, the mean of the PEN (4.00) is situated in a high degree of perception, distinguishing two differentiated groups in the perception of the enjoyment of the methodology. One of them is at low levels (2.8) with respect to the standard deviation of the mean and the other is at very high levels (5.2), showing a "gap" in the enjoyment of the maker methodology.

Regarding the Attitude towards use (ACU) subscale, a normal distribution of attitudes is observed (S-W sig. > 0.05), with percentage distributions very similar to the previous subscale of Perceived enjoyment. In this case, the attitude towards the methodology is mostly perceived as High (44.74%) or Very High (15.79%), but a reduction of the intermediate level is also observed, which increases again in the Low level of attitude. This suggests, once again, the distinction of two antagonistic groups in terms of attitude towards the methodology. On the one hand, a sector where the score is positioned below the average (3.97) and which obtains results around -S (2.69) and, on the other hand, a proactive sector towards the methodology with a very high attitude (5.25).

The Intention to use (IU) subscale, on the other hand, presents a normal distribution, with a more equal distribution among the levels, although with a high range (5). Nevertheless, 50.00% of the pre-service teachers show a high intention to use the pedagogical maker methodology in the near future, adding 7.89% who think that they have a very high intention to use it. In this case, (15.79%) are neutral or medium, while 25.05% state that the perception of using it is low (21.05%) or very low (5.26%). In this case, the majority group that is in favour of the intention to use the methodology presents a high level of acceptance (4.98), compared to the group that is more inclined not to use the maker methodology in the near future (2.68 points).

Finally, with regard to the global Technology acceptance model (TAM), a normal distribution is observed (S-W sig. > 0.05), with a high variability among the values, which fluctuate from the minimum value of 1.25 to the maximum value of 5.53, with a range of 4.28 points. These overall scores of the instrument are distributed among the different levels as follows. On the one hand, the Very Low value represents 2.63% (1 individual). This individual has an average of 1.25 throughout the instrument. The Low value accumulates a mean of 2.57 points, with a standard deviation of 0.41, and accounts for 23.68% of the participants(9 individuals). On the other hand, the intermediate value in terms of acceptance of the maker methodology represents 21.05% (8 individuals) with a mean of 3.77 and a standard deviation of 0.23. The High level has a mean (4.45) and a standard deviation (0.31) that represent 42.11% of the sample (16 individuals) and, finally, the Very High level has a mean of 5.34 and a standard deviation of 0.20 over 10.53% (4 individuals).

As with the RIMMS, there is a minority of participants in the TAM who are less receptive to the Maker approach, and who are below the TAM average (3.88), with an average level of perception at the low level (2.84).On the other hand, there is a majority of the participants are positioned at a high level of acceptance (4.92) or practically very high. In this sense, we can affirm that the level of acceptance of the maker methodological approach, in terms of the students' perception of its usefulness, ease of use, enjoyment and intention to use it, together with the general acceptance of the maker model (TAM), has been very favorable and highly accepted.

9 Level of general acceptance influences the level of motivation

In order to find out the possible influence of the level of general acceptance (TAM) on the level of motivation (RIMMS), first, we will begin to pose the null and alternative hypotheses based on the following assumptions:

H0: the level of general acceptance (TAM) does not influence the level of motivation (RIMMS).

H1: the level of general acceptance (TAM) influences the level of motivation (RIMMS)

First, we will proceed to plot the relationship between the two variables (Fig. 3) in order to establish a relationship between the two instruments and propose the best correlation model. Through the curvilinear estimation regression analysis, we can choose the optimal option to explain the relationship between the independent variable (TAM) and the dependent variable (RIMMS). By interpreting the best fits for the correlation model, it is concluded that the most optimal and adjusted model is the linear correlation model (Table 6) with a high degree of correlation (R = 0.952) and a significance level of < 0.001. Proceeding to the linear regression analysis to predict, with a 95% confidence level, the changes in the level of RIMMS motivation when there is an increase in the level of general acceptance (TAM).

Subsequently, as can be observed, we proceed to verify that the scores obtained from the values observed in both variables (TAM and RIMMS) are highly correlated

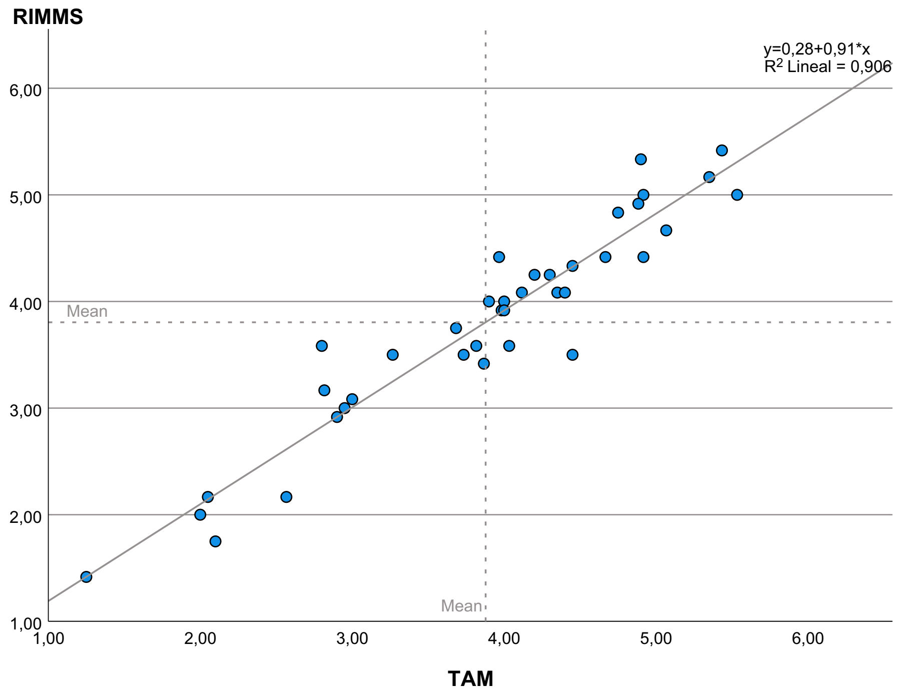

Fig. 3 Scatter plot between TAM and RIMMS variables

on the linear regression line drawn and explain the changes of 90.6% of the dependent variable (R2 = 0.906) and it is a significant correlation (< 0.001). The relationship is direct and positive, and interprets that as the level of acceptance of the maker methodological approach increases, in turn, the level of motivation in the process of designing projects based on this methodology increases. In this sense, the linear regression model obtained is: Y' = 0.28 + 0.91*X, i.e., a change in the TAM variable will generate a predicted increase in the RIMMS variable in the sense of the equation described (Table 7).

Lastly, after performing the appropriate analysis of the correlation and linear regression model, we can conclude that there is sufficient evidence to reject the null hypothesis (H0) and accept the alternative hypothesis (H1). The level of acceptance of the maker methodological approach in terms of students' perception of its usefulness, ease of use, enjoyment and intention to use it, has a significant influence ($p < 0.001$) on the level of motivation.

10 Discussion

This study has analyzed the level of acceptance perceived by pre-service early childhood teachers towards maker education and their motivation.

The value of this research derives from the pressing necessity created by the swift and continuous emergence of novel technologies to establish transformative

Table 6 Results of Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	,952[a]	,906	,903	,30800	,906	346,757	1	36	< ,001	2,078

a. Predictors: (Constant), TAM.

b. Dependent Variable: RIMMS.

Table 7 Coefficients

Model	Unstandardized Coefficients	Standardized Coefficients				95,0% Confidence Interval for B	
	B	Std. Error	Beta	t	Sig	Lower Bound	Upper Bound
1 (Constant)	,282	,196		1,442	,158	-,115	,679
TAM	,908	,049	,952	18,621	< ,001	,809	1,007

pedagogies in the educational sector. Such pedagogies empower students with the tools and competencies needed to meet the demands of the contemporary twenty-first century society (Yelland and Arvanitis, 2018). Several previous studies have highlighted the need for further research in the area of maker education, specifically in providing a formal maker training that prepares future teachers to effectively integrate maker pedagogical approaches into educational practices and assume the role of makerspace instructors (Rouse & Rouse, 2022). Our research aligns with previous ideas and presents meaningful data that contributes to the advancement of maker approaches in the context of formal education.

The main finding of this research indicates that the motivation towards maker education increases as the level of acceptance of the maker methodological approach increases. This outcome supports the contributions of other researchers in this field (Hughes et al., 2019; Kwon & Lee, 2017). Chu et al. (2016) investigated the acquisition of general acceptance from instructors in order to facilitate their role as curriculum designers. Hsu et al. (2017) note that an increasing number of educators must possess the requisite knowledge, theories and abilities necessary to integrate maker education into formal learning environments.

The analysed data from the questionnaires revealed that the future teachers are generally satisfied with the integration of maker education and are highly motivated towards its implementation in the teaching and learning practice. It should be noted that in nearly all instances of the analyzed variables, both in TAM and RIMMs, the most commonly recurring outcome has been the high category. Similar research in this field (O'Brien et al., 2016; Marsh et al., 2019; Paganelli et al., 2017) likewise confirms these optimistic attitudes towards the implementation of maker education.

In view of the results, the dimensions of relevance and confidence have been better valued in terms of motivation. Further exploration of the confidence factor is supported by similar research, specifically the study undertaken by Heredia and Tan (2021), which demonstrates a positive transformation in two teachers' confidence, understanding, enthusiasm and mindset after using making as a pedagogical approach. Previous research has also demonstrated that when novice educators receive support for professional growth and become familiar with this pedagogy, they feel more confident in its use and implementation (Shively et al., 2021a, b).

Concerning the Technology Acceptance Model, the high intention to use it (IU) result could be associated with a willingness to engage in designing effective plans positioning educators as effective contributors to the implementation of transformative pedagogy.

According to the perceived ease of use (PEU) dimension, although most of the subjects considered the ease of use of the maker methodology to be high, for the rest of the subjects it was medium–low, which leads us to conclude that there is an unequal perception of ease of use. This idea may be attributable to the distinct working style in a makerspace compared to that of a traditional school (Iwata et al., 2020). For most research participants, working with an innovative method represented a considerable challenge. The disparate viewpoints could potentially be resolved by establishing a maker identity through ongoing professional development programmes that offer assistance and direction in creating and executing maker initiatives (Jones et al., 2020; Pitkänen et al., 2019). Practical implementation and active involvement may be utilised to surmount the learning curve connected to acquiring novel technologies (Chen & Cao, 2022). Enabling pre-service teachers to implement their designs in real school settings could be another strategy employed to address this perception. This allows them the freedom to learn from failure and gain valuable experience.

The findings of a high level of enjoyment (PEN) and a high level of attitude towards its use (ACU) show that future teachers feel that using Maker Education is enjoyable, that they believe it is a good idea to use it, and that the learning process becomes more interesting when using Maker Education. This supports the idea that teachers should include activities in their teaching and learning plans that allow students to have agency, rather than simply replicating existing projects (Hynes & Hynes, 2018). Maker education has been shown to have the potential to help learners become active problem solvers and active members of the teaching and learning process (Chu et al., 2015; Hira & Hynes, 2018) and its inclusion helps to develop certain concepts such as personal agency, self-esteem and self-efficacy (Papavlasopoulou et al., 2017).

11 Conclusion

Education should ensure that students are given the opportunity to design and build their ideas with and through technology, rather than simply being users or consumers.

In this research, there are a number of limitations to be considered, firstly the data was collected within a university context and in a specific degree, in this case Early Childhood Education. A future research study could include and compare data from other degrees such as Primary Education. Another limitation of the study was the sample. Future work should also include the analysis of other variables such as student characteristics (e.g. gender, age or the digital competence level). It would also be worthwhile in future studies to compare the results obtained with another group to whom the maker method has only been explained theoretically, but who have not designed teaching and learning plans based on the maker methodological approach.

To conclude it must be underlined that the current study can be helpful for instructors to get a better insight on designing more maker based proposals in their teaching practice, considering the high level of motivation and acceptance level that this approach has shown to have. It may be the key to support the creative, innovative and entrepreneurial side of education, similarly to the research that supports the use of the maker educational approach (Jin et al., 2021; Wang & Shan, 2019).

The practical significance of this study is highlighted by its potential to revolutionise academic pre-service teaching programmes. By elevating the importance of maker pedagogy and integrating it into these programs, future educators may be better equipped to use innovative teaching techniques. In relation to these previous ideas, this research aims to highlight the transformative capacity of maker education through rigorous educator training.

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Data Availability Data supporting this study are not publicly available.

Declarations

Informed consent Data collection and processing for this study were conducted anonymously. Participants were provided with comprehensive information about the study, and only those who voluntarily chose to participate completed the questionnaire.

Ethical approval The Ethics Committee of the University of the Basque Country has approved the conduct of this research.

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Conflict of interest None.

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