Assessing the Effectiveness of Using Fab Lab-based Learning in Schools on K-12 Students' Attitude Toward STEAM

Mohammed Amine Togou, Covadonga Lorenzo, Gianluca Cornetta and Gabriel-Miro Muntean

Abstract— *Contribution:* **This study presents the NEWTON Fab Lab Education Initiative which aims at assessing the effectiveness of Fab Lab-based learning on K-12 students' attitude toward learning STEAM considering two aspects: 1) students' motivation and affective state; and 2) students' observations and perception of Fab Lab-based learning.**

Background: **Fabrication laboratories (Fab Labs) are described as small workshops equipped with a set of computer-controlled tools (*e.g.,* 3D printers) that offer personalized digital fabrication. They have been shown to have a positive impact on learners' academic and personal progress when used in extra-curricular activities. Yet, there is little research that examines whether integrating Fab Labs into schools' curricula can help raise students' interest in STEAM education.**

Research Question: **Can Fab Lab-based learning foster students' interest in STEM in primary and secondary schools? Would students be keen to use Fab Labs in their science classes?**

Methodology: **Two case studies were carried out in two different schools as part of the European Horizon 2020 NEWTON project. 39 participants took part in the study and three different surveys were used to assess different constructs.**

Findings: **Results show that after using the Fab Lab-based learning: 1) students felt more interested in science classes as well as more engaged and less bored; and 2) while some students struggled at first when manipulating Fab Lab tools, they adapted quickly and reported that they would like to use Fab Labs as part of their science classes.**

Index Terms— **Collaborative Learning, Digital Fabrication, K-12 Education, Remote Laboratory, STEAM.**

I. Introduction

THE number of jobs that will depend on Technology, Engineering, Art and Mathematics (STEAM) skills is increasing, and such careers are among the fastest growing worldwide. Still, the gap between the job market demands and the availability of these skills keeps growing. A key factor contributing to this situation is the drop in the number of graduates in STEAM-related studies, which starts before college. Archer *et al.* [1] reported that students choose whether or not to study science before the age of fourteen. These choices are made based on their school experience of STEAM [2]. Kelly [3] and George [4] reported a decline in attitude toward science as pupils progress through secondary school. According to the US National Science Board [5], only 19% of ninth grade students enrolled in calculus, 38% enrolled in biology and 42% enrolled in physics. This is because STEAM traditional teaching methods are often seen as dull and obsolete [6]. In addition, STEAM concepts are usually taught independent of one another and are not associated with real-life problems that might be relevant to students. As secondary school coursetaking has significant implications for academic and career trajectories [7], it is of paramount importance to rally all efforts in order to promote students' interest in STEAM courses that will prepare them for the future.

According to the *expectancy-value theory* [8], people choose to take on a challenging task (*e.g.,* enrolling in a science class in secondary school) if they value the task and they expect to succeed in it. Valuing a task includes intrinsic aspects such as engagement and enjoyment experienced while performing the task along with how useful and relevant the task is (*i.e.,* learning new skills that can be used in other life aspects). Correlation research [9]-[12] shows that when students perceive value in course topics, they develop interest and take more advanced courses in related academic disciplines.

Recent studies [13]-[17] indicate that creative use of technology in education can spark students' engagement in learning. Fabrication Laboratories (Fab Lab) - small workshops that are equipped with a set of computer-controlled tools (*e.g.,* 3D printers, laser and vinyl cutters and milling machines) offering personalized digital fabrication - have been shown to have a great impact on students' academic performance and personal growth [13], [18]-[20]. For instance, Berry *et al.* [13] suggested that teaching STEAM via tasks that make use of digital fabrication can help students learn faster and be more engaged. Angello *et al.* [21] reported that Fab Labs can improve students' experience of *fun while learning*. Tesconi [22] showed that Fab Labs can help students develop their critical thinking skills and boost their self-esteem, which can help them deal with problems and making decisions. Chu *et al.* [23] showed that they can develop students' self-efficacy and self-identification while Eversmann [24] reported that using Fab labs can make students keener to self-learning.

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Despite endorsing the utility value (*i.e.,* how useful the task is), uncertain and unknown is the extent to which Fab Lab-based learning (*i.e.,* using Fab Labs as in-class support tool) can influence students' attitude in primary and secondary schools toward learning STEAM. To the best of the authors' knowledge, none of the existing studies have considered this aspect. This paper presents the NEWTON Fab Lab Education Initiative (NFEI) which aims at examining the impact of Fab Lab-based learning on students' attitude toward leaning STEAM. It deploys a collaborative design-based Science (DBS) approach, which is seen as a catalyst for improving STEAM education as it enables students to acquire in science classes the knowledge and skills necessary to solve real-world problems [25]-[30]. The research study is part of the EU Horizon 2020 NEWTON project [31]. The NEWTON project[1] has designed and deployed innovative technology-enhanced learning techniques, including support for virtual and remote labs [32], adaptive and personalized rich media delivery [33], gamification [34] and game-based learning [35]. This paper reports on the results of two case studies from two schools (*i.e.,* one primary and one secondary) in which Fab Lab-based learning was deployed. The goals of the study were as follows:

- Investigate how Fab Lab-based learning can influence primary and secondary school students' attitude toward learning STEAM. The goal is to motivate these students to pursue advanced STEAM courses by helping them perceive value in those courses. This will provide valuable information for educators, school administrators and the educational research community as they continue to seek new ways to encourage students to pursue STEAM courses.
- Assess students' perceptions of Fab Lab-based learning in primary and secondary schools. Researchers report high students' satisfaction with Fab Lab-based learning in second level and third-level education [13], [14], [17], [19], [20], [22], [24]. However, very few studies consider students' viewpoint with respect to Fab Lab-based learning in primary-level education.

II. NEWTON Fab Lab Education Initiative

When designing NFEI, a set of steps [14] were followed:

1. **Specification of the pedagogical objectives:** FEI aims at enabling students to learn different theoretical concepts from different disciplines using a hand-on approach as well as helping them develop skills such as problem solving and teamwork.
2. **Choice of the study model:** to achieve the pedagogical objectives, NFEI endorses an investigation model where students need to work together to design prototypes using the theoretical concepts acquired in class.
3. **Choice of technologies/software components:** the technologies used in NFEI's activities were selected based on CEU Fab Lab's equipment. As for software components, open-source software was adopted because of the broad support from community.
4. **Development of the lessons:** NFEI's lessons were developed in collaboration with the participating teachers. The teachers provided the learning goals of the science classes and the project research team, with the help of pedagogical experts, designed the lessons through which these learning outcomes can be achieved.
5. **Pedagogical quality control:** extensive interaction with teachers was carried out during multiple stages of the lessons' development, including detailed description of each lesson and learning outcomes assessment, to obtain approval. Following teachers' feedback, all elements raised were modified and adjusted.

NFEI's initial deployment focuses on 3D printing. It has three activities. The first focuses on geometry, perceived to be very difficult by most students in primary and secondary schools. The goal is to help students improve their visual imagination and their understanding of graphic projections. It involves the design and the fabrication of ceramic vases using 3D printers. The second focuses on teaching students physics and math concepts (*e.g.,* form analysis and spatial reasoning) through the design and fabrication of a 3D mini rocket while the third aims at teaching students coordination and teamwork through the fabrication of a 3D prosthesis hand.

The research study presented in this paper involves the first activity only. It has five stages:

1. Students study the shapes (*e.g.,* prism, square, triangle and rectangle) that are used to construct the ceramic vases following the teacher-based approach. Then, they draw on paper a 2D representation of the ceramic vase they want to fabricate.
2. Students design the ceramic vases using *FreeCAD*[2]. Each vase is made of three parts: top, middle and bottom, and is fabricated by a team of three students, each of whom oversees the fabrication of one part.
3. student generate the stereolithographic files and use *Ultimaker Cura*[3] to prepare the files that will be sent to the 3D printer.
4. Students send the files to the 3D printer located in CEU San Pablo University, Spain via the *NEWTELP*[4] platform.
5. Students are given a short presentation that explains how the 3D printer will fabricate the modelled vases.

Please refer to [32] and [36] for more details about the 3D printing lesson.

III. Method

Over the course of this study, we worked with two schools: Saint Patrick's Boys National School (B.N.S) in Dublin, Ireland and CEU Monteprincipe School in Madrid, Spain. The former is a primary school while the latter is a secondary school. Prior to undertaking the case studies, ethical approval was obtained from Dublin City University and San Pablo University Ethics Committees. We worked closely with the schools' principals to identify the classes that can participate considering three criteria: class curriculum, teachers'

[1] http://www.newtonproject.eu

[2] https://www.freecadweb.org/

[3] https://ultimaker.com/en/products/ultimaker-cura-software

[4] https://newtelp.eu/

LEARNER UNIQUE NEWTON ID Number:					
Science Classes before NEWTON					
1. Please rate how interested you are in your Science classes?	Not at all interested	Slightly interested	Somewhat interested	Very interested	Extremely interested
2. How confident are you that you can solve any/all of the problems and challenges you experience in your science classes?	Not at all confident	Slightly confident	Somewhat confident	Very confident	Extremely confident

(a)

LEARNER UNIQUE NEWTON ID Number:					
Usefulness					
1. It helps me be more effective in a science class	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
2. It is useful.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
3. It saves me time when I use it.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

(b)

Fig. 1. Sample of the questionnaires' questions: a) Learner's Motivation and Affective State (pre) and b) Learner's Usability

willingness to participate in the study and students' ability to use computers. The latter is to comply with the schools' timetable as students who are not familiar with computers may face difficulties interacting with the software tools used in our study and therefore might not finish the activities in the time allocated. We then reached out to the teachers directly to invite them to participate. Consent forms were provided to parents and assent forms were signed by students willing to participate in this study. A description of the project and the research study were provided in a plain language statement and the data management plan was also made available to both parents and students. A description of the project and the research study were provided in a plain language statement and the data management plan was also made available to both parents and students.

The participants were 39 sixth and seventh grade students aged between 10 and 13. 87% of the sample identified as male and 26% of the participants were gifted students. Each case study lasted for a week and consisted of three sessions. In the first session, students were asked to apply concepts learned in class to model the ceramic vases while in the second session, students were required to design the modelled vases using FreeCAD software. In the last session, students were required to prepare the 3D files using Ultimaker Cura and to send them to the remote 3D printer.

The core of the evaluation procedure employed in this pilot was developed by the NEWTON project's Pedagogical Assessment Committee (PAC) [33] and was used in all the project's pilots. It provides templates and guidelines for various assessments, including: *Learner Demographics* questionnaire, *Learner Motivation and Affective State* questionnaires and *Learner Usability* questionnaire. The Learner Motivation and Affective State questionnaires assess learners' attitude toward learning STEAM and their emotions while learning before (Pre) and after (Post) using Fab Lab-based learning. They had six 1-item constructs, each of which was measured on 6-point Likert scale anchored by *strongly disagree* and *strongly agree* or *not at all* and *extremely*. Fig. 1(a) illustrates two such constructs. The Learner Usability questionnaire, on the other hand, assesses learners' perception of the Fab Lab-based learning experience and had four constructs, each of which was measured on a 5-point Likert scale anchored by *strongly disagree* and *strongly agree,*

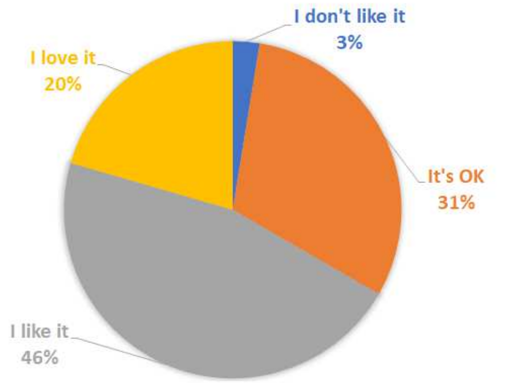

Fig. 2. Students' feeling about learning Science, Technology and Math

TABLE I
STUDENTS' INTEREST IN SCIENCE CLASSES

	St. Patrick's B.N.S (n = 29)		CEU Monteprincipe (n = 10)	
	Pre	Post	Pre	Post
Mean	3.52	4.41	3.90	4.60
SD	0.97	0.46	0.99	0.27
SE	0.18	0.086	0.31	0.08
p	< 0.001		0.0095	
d_{av}	1.17		0.96	

SD: Standard Deviation; *SE*: Standard Error; d_{av}: Effect size

achieving high reliability:

1. *Usefulness*: a 3-item construct ($\alpha = 0.83$) (see Fig. 1(b)).
2. *Ease of use*: a 3-item construct ($\alpha = 0.91$).
3. *Ease of learning*: a 2-item construct ($\alpha = 0.97$).
4. *Satisfaction*: a 3-item construct ($\alpha = 0.83$).

Note that learners' observational assessment was carried out by researchers present during the case studies and interviews were conducted after each case session was completed.

IV. RESULTS

When filling the Learner Demographic questionnaire, students were asked to rate their feelings in relation to learning Science, Technology and Math subjects (see Fig. 2). Most of the answers in both schools ranged between *I like it* and *I love it*. These results are encouraging as NFEI seeks to enable these students to maintain the same attitude or boost it. Still, what is interesting is that 31% of the participants answered *It's OK*. These students are uncertain about whether they like learning STEAM or not, making them predisposed to early disengagement from STEAM studies.

A paired T-test for means with $\alpha = 0.05$ was used to check for statistical significance between results of Learner's Motivation and Affective State questionnaires (pre and post). When asked about their interest in science classes, students in both schools showed more interest after using Fab Lab-based learning (Table I). A comparison between the pre and post results revealed statistically significant improvements of 22.4% (d_{av} = 1.17, g_{av} = 1.14 and 95% with Confidence Interval (CI) [0.66,1.12]) for St. Patrick's B.N.S and 16.5% (d_{av} = 0.96, g_{av} = 0.88 with 95% CI [0.13,1.27]) for CEU

TABLE II
STUDENTS' CONFIDENCE ABOUT SOLVING PROBLEMS IN SCIENCE CLASSES

	St. Patrick's B.N.S (n = 29)		CEU Monteprincipe (n = 10)	
	Pre	Post	Pre	Post
Mean	2.93	3.28	3.80	4.10
SD	0.78	0.99	1.07	0.77
SE	0.14	0.18	0.34	0.24
p	< 0.001		0.081	
d_{av}	0.39		0.32	

TABLE III
STUDENTS FEELINGS ABOUT LEARNING IN SCIENCE CLASSES

To what extent do you agree or disagree with the following:		St. Patrick's B.N.S (n = 29)		CEU Monteprincipe (n = 10)	
		Pre	Post	Pre	Post
I feel positive about learning in science classes	Mean	3.71	4.21	3.90	4.30
	SD	1.03	0.54	0.77	0.23
	SE	0.19	0.10	0.24	0.07
	p	< 0.001		0.037	
	d_{av}	0.61		0.70	
I feel enthusiastic about learning in science classes	Mean	2.85	4.18	2.40	3.80
	SD	0.98	0.69	1.16	0.40
	SE	0.19	0.13	0.37	0.13
	p	< 0.001		< 0.001	
	d_{av}	1.57		1.61	
I would like to use more technology in science classes	Mean	4.14	4.41	4.60	4.50
	SD	1.55	0.46	0.27	0.28
	SE	0.29	0.09	0.08	0.09
	p	0.088		0.343	
	d_{av}	0.24		0.36	

Monteprincipe. The common language effect size (CL) indicates that after controlling for individual differences, the likelihood that a student feels more interested in STEAM subjects is 93% for St. Patrick's B.N.S and 81% for CEU Monteprincipe.

In addition, students in both schools felt more confident about solving STEAM problems after using Fab Lab-based learning (Table II). A Comparison between pre and post results showed a statistically significant improvement of 11.3% (d_{av} = 0.39, g_{av} = 0.38 with 95% CI [0.16,0.54]) for St. Patrick's B.N.S of 11.3% (d_{av} = 0.39, g_{av} = 0.38 with 95% CI [0.16,0.54]) for St. Patrick's B.N.S and an improvement of 7.6% of no statistical significance (d_{av} = 0.32, g_{av} =0.29 with 95% CI [-0.08,0.68]) for CEU Monteprincipe. After analyzing individual differences, the CL effect size indicates that the likelihood that a student feels more confident about solving STEAM problems is 76% and 71% for St. Patrick's B.N.S and CEU Monteprincipe, respectively.

Moreover, students in both schools appeared to be more enthusiastic and more positive about learning after using Fab Lab-based learning (Table III). Results showed statistically significant improvements of 37.8% (d_{av} = 1.57, g_{av} = 1.48 with 95% CI [1.09,1.57]) and 12.6% (d_{av} = 0.61, g_{av} = 0.59 with 95% CI [0.26,0.74]) for St. Patrick's B.N.S and 45.2% (d_{av} = 1.61, g_{av} = 1.52 with 95% CI [0.77,2.03]) and 9.8\% (d_{av} = 0.70, g_{av} = 0.64 with 95% CI [-0.02,0.82]) for CEU Monteprincipe in terms of enthusiasm and positivism, respectively. the CL effect size indicates that after controlling for individual differences, the likelihood that a student feels more enthusiastic about learning is 98% at St. Patrick's B.N.S and 94% at CEU Monteprincipe. The CL effect size indicates also that the likelihood that a student feels more positive about learning is 79% and 75% at St. Patrick's B.N.S and CEU Monteprincipe, respectively. Note that the vast majority of students in both schools would like to use more technology in science classes. Comparison between pre and post results showed an improvement of 6.3% for St. Patrick's B.N.S d_{av} = 0.24, g_{av} = 0.24 with 95% CI [-0.20,0.74]) and 2.2% decline for CEU Monteprincipe (d_{av} = 0.36, g_{av} = 0.33 with 95% CI [-0.018,0.22]). However, these findings are not statistically significant.

TABLE IV
STUDENTS EMOTIONS WHILE LEARNING IN SCIENCE CLASSES

While learning in your science class, to what extent did you feel the following:		St. Patrick's B.N.S (n = 29)		CEU Monteprincipe (n = 10)	
		Pre	Post	Pre	Post
Engaged	Mean	3.10	4.07	3.60	4.60
	SD	1.45	0.85	0.27	0.27
	SE	0.27	0.16	0.84	0.84
	p	< 0.001		< 0.001	
	d_{av}	0.82		3.70	
Enjoying	Mean	3.65	4.48	3.90	4.80
	SD	1.38	0.33	1.66	0.18
	SE	0.26	0.06	0.52	0.06
	p	< 0.001		0.019	
	d_{av}	0.82		0.76	
Bored	Mean	1.82	1.34	1.80	1.20
	SD	0.79	0.31	0.62	0.18
	SE	0.16	0.06	0.20	0.06
	p	< 0.001		0.0051	
	d_{av}	0.82		1.31	

Furthermore, students rated their emotions while learning before and after using Fab Lab-based learning (Table IV). Comparison between the average scores of the pre and post results showed statistically significant improvements of 27.1% (d_{av} = 0.82, g_{av} = 0.79 with 95% CI [0.67,1.27]) and 20.42% (d_{av} = 0.82, g_{av} = 0.80 with 95% CI [0.39,1.45]) for St. Patrick's B.N.S and 24.4% (d_{av} = 3.70, g_{av} = 3.38 with 95% CI [0.73,1.27]) and 20.7% (d_{av} = 0.76, g_{av} = 0.69 with 95% CI [-0.2,2.0]) for CEU Monteprincipe in terms of engagement and enjoyment, respectively. Results also showed statistically significant declines in boredom of 30.4% (d_{av} = 0.82, g_{av} = 0.79 with 95% CI [0.28,0.70]) for St. Patrick's B.N.S and 40% (d_{av} =1.31, g_{av} = 1.20 with 95% CI [0.25,0.94]) for CEU Monteprincipe. After controlling for individual differences, the CL effect size indicates that the likelihood that a student feels more engaged, enjoying and less bored is 89%, 77% and 81% for St. Patrick's B.N.S; and 99%, 72% and 89% for CEU Monteprincipe.

In terms of gender differences, we compared results of female and male students from CEU Monteprincipe. Results showed that female students had an improvement of 18% in terms of interest in science classes compared to male students (only 5%). Female students also had an improvement of 34% ($t(5)$ = 3.5, p = 0.0249) in terms of engagement compared to male students (only 15% with no statistical significance). Finally, female students witnessed a decrease in boredom of 74% compared to 29% for male students. Note that Fisher's exact test was used to test for any significance between the results obtained at the two institutions for the various aspects, but none was found.

Fig. 3 depicts the average scores of the four constructs of the Learner Usability questionnaire. Despite the satisfactory usability assessment (*i.e.,* of all the participants from both schools, 87% reported that they had fun using Fab Lab-based learning and indicated that they would recommend them to their friends), there is still room for improvement, particularly in terms of ease of use. Indeed, few students in this study, mainly from St. Patrick's B.N.S, reported that they struggled hard to finish the various activities (*i.e.,* 34% of the participants from St. Patrick's B.N.S stated that the tools were not easy to use while 62% said that they cannot use them without referring to the tutorials). A possible solution would be to organize multiple tutorial sessions for the participants in order to become acquainted with the different tools used.

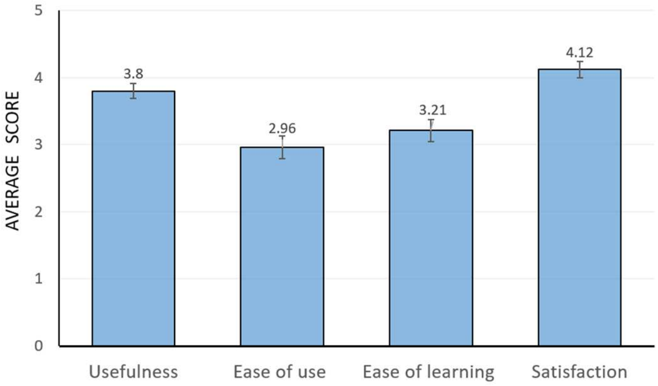

Fig. 3. Average scores of the four scales of the Learner Usability questionnaire.

V. Discussion

Students showed more interest in science classes after using Fab Lab-based learning. This pattern occurred in both schools with an effect size that exceeded 1 in St. Patrick's B.N.S. Emotions while learning were explored to understand why this pattern has occurred

While students from both schools witnessed high effect sizes in terms of *engagement*, the ones at CEU Monteprincipe scored almost 4. The rich educational experience that Fab Lab-based learning offers enabled students to reflect, question, evaluate, collaborate and make connections between ideas. This aligns with the findings of previous studies which indicate that motivation [38] and the creative use of technology in education and the creative use of technology in education [13]-[17] can spark students' engagement in learning. Indeed, students who completed the design session ahead of time started designing their own 3D object, some of which looked pretty complex as they incorporated different shapes with different sizes.

Students in both schools enjoyed learning using Fab Lab. This emotion was distinctly manifested by students' cheer and applause when successfully completing a task/activity. Such feeling is essential in stimulating students' motivation to engage actively in the learning process [39]. Numerous students stated that they wished that the sessions would have been longer so that they can create other 3D objects. This is well justified by the determination theory, which asserts that activities a person enjoys are more intrinsically motivating than those activities the person does not enjoy [40].

Finally, students in both schools felt less bored when learning with Fab Lab. When quantifying the boredom effect size, it can be said that the score of students at CEU Monteprincipe exceeded 1. This is very promising given that students get bored for half the class's duration on average [41]. The lack of boredom was clearly exhibited by students' full concentration on the task at hand as they found it interesting and relevant, which led them to lose track of time. Indeed, after finishing the research study, many students stated that time has passed so quickly and that it is one of the rarest occasions where they felt this way at school. This suggests that integrating Fab Lab technologies within schools' curricula can help students reach their cognitive and metacognitive potential faster [42] and reduce both absenteeism [43]-[45] and dropout rates [46], [47].

VI. Limitations and Implications

A. Limitations

Due to the timeline of the research study which was rather short (*i.e.,* six months in total, from research question generation to conducting and analyzing the various results), we encountered difficulties in finding schools willing to participate in the research study. Still, we believe that the findings presented in this paper can be used as groundwork for future studies to: 1) shed light on the various factors that can impact the relationship between using Fab Lab-based learning and raising students' interest in STEAM subjects; and 2) confirm that these findings are not unique to the institutions who took part in the research study.

Another limitation is that examining the impact of Fab Lab-based learning on students' performance and school enjoyment was not carried out in this paper. We believe that such study is of paramount importance. Indeed, 93% and 30% of students from St. Patrick's B.N.S and CEU Monteprincipe, respectively, expressed their impartiality with respect to their attitude toward school. This raises serious concerns since disliking school may have negative impact on academic aspiration [48], [49] and may lead to high school dropouts [50], jeopardizing all the efforts put forward to encourage students to pursue STEAM careers.

B. Implications

The findings of this study highlight the relationship between using Fab Lab-based learning and stimulating students' interest in STEAM. Still, large scale qualitative studies are required to verify the generalization of such findings. Learners nowadays prefer an education that is interesting, fun and technology-oriented [51], and this is precisely the goal of NFEI: promoting STEAM learning as a process which is fun, interesting and very appealing to contemporary students' mindset. To this end, we are planning to run two large-scale pilots in two different European countries (*i.e.,* Italy and

Romania). We intend to engage more female participants to test for gender differences and to check whether the findings of this study can be generalized.

Large scale qualitative studies can also be used to identify and implement strategic interventions that can help K-12 students boosting further their interest in STEAM. These interventions can be embodied into NFEI and can take various forms, including helping teachers developing their own Fab Lab content to better fit their courses, enabling students to access Fab Lab technologies anywhere anytime, organizing competitions among schools requiring students to come up with innovative solutions to real-world problems that can benefit the entire community, and designing new activities that combine Fab Lab technologies with AR/VR and robotics to enable students to build twenty-first century skills.

VII. Conclusion

The major conclusion of this study is that using Fab Lab-based learning can help foster K-12 students' interest in STEAM. Participants in this study reported that they felt more confident about solving problems in science classes and that they were more engaged, happier and less bored compared to the conventional teacher-based approach. They also stated that they would like to use more technology in science classes and that they are inclined to integrating Fab Lab technologies in schools' curricula. Because of the high setup and maintenance costs of Fab Labs, only few schools can afford them. NFEI is a way to democratize access to Fab Lab technologies to large school communities, increasing therefore the number of students who can benefit from this initiative and promoting the idea that STEAM can be fun and interesting.

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