PROJECT-BASED LEARNING APPLIED TO INITIAL AND CONTINUING TRAINING COURSES IN THE MAKER CULTURE

APRENDIZAGEM BASEADA EM PROJETOS APLICADA A CURSOS DE FORMAÇÃO INICIAL E CONTINUADA EM CULTURA MAKER

APRENDIZAJE BASADO EN PROYECTOS APLICADO A CURSOS DE FORMACIÓN INICIAL Y CONTINUA EN LA CULTURA MAKER

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ABSTRACT: This article presents the use of the Project-Based Learning (PBL) methodology as a practical method for the execution of two 40-hour Initial and Continuing Training (ICT) courses in the Maker Culture area for the hybrid class format with teams formed by undergraduate students in Control and Automation Engineering from the Federal Institute of Amazonas Campus Manaus Distrito Industrial (IFAM CMDI), developed over 14 weeks. Providing students with training in this area has become an even greater challenge because it took place during the Covid-19 pandemic period. At the end of the courses, all 36 participating students filled out a form presenting their perceptions of the courses. The results indicated a positive evaluation of the activities, highlighting the relevance of practical activities throughout the courses so that they did not become tiring, preventing students from dropping out. It is considered important to include remote research and guidance activities, together with face-to-face activities in a maker space using the PBL, which allowed the application of the contents in projects of interest to the students, fixing the contents taught.

KEYWORDS: Project-based learning. Maker culture. Initial and continuing training.

RESUMO: *Este artigo apresenta a utilização da metodologia de Aprendizagem Baseada em Projetos (ABP) como um método prático para a execução de dois cursos de Formação Inicial e Continuada (FIC) de 40 horas cada, na área de Cultura Maker para o formato híbrido de aula, com equipes formadas por acadêmicos de graduação em Engenharia de Controle e Automação do Instituto Federal do Amazonas, Campus Manaus, Distrito Industrial (IFAM CMDI), desenvolvido ao longo de 14 semanas. Levar aos alunos à formação nesta área se*

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tornou um desafio ainda maior por ter ocorrido durante o período de pandemia de Covid-19. Ao final dos cursos, todos os 36 discentes participantes preencheram um formulário apresentando suas percepções dos cursos. Os resultados indicaram a avaliação positiva das atividades, destacando a relevância das atividades práticas ao longo da realização dos cursos para que estes não se tornassem cansativos, evitando a desistência dos discentes. Considera-se importante a inclusão de atividades de pesquisa e orientação remotas, juntamente com atividades presenciais em um espaço maker utilizando a ABP, a qual permitiu a aplicação dos conteúdos em projetos de interesse dos discentes, fixando os conteúdos ensinados.

***PALAVRAS-CHAVE**: Aprendizagem baseada em projetos. Cultura maker. Formação inicial e continuada.*

***RESUMEN**: Este artículo presenta el uso de la metodología de Aprendizaje basado en Proyectos (ABP) como método práctico para la ejecución de dos cursos de Formación Inicial y Continua (FIC) de 40 horas en el área de Cultura Maker para el formato de clase híbrida con equipos formados por estudiantes de pregrado en Ingeniería del Control y Automatización del Instituto Federal de Amazonas Campus Manaus Distrito Industrial (IFAM CMDI), desarrollado durante 14 semanas. Capacitar a los estudiantes en esta área se ha convertido en un desafío aún mayor porque se llevó a cabo durante el período de pandemia de Covid-19. Al final de los cursos, los 36 estudiantes participantes llenaron un formulario presentando sus percepciones de los cursos. Los resultados indicaron una evaluación positiva de las actividades, destacando la relevancia de las actividades prácticas a lo largo de los cursos para que no se vuelvan agotadoras, evitando la deserción de los estudiantes. Se considera importante incluir actividades de investigación y orientación a distancia, junto con actividades presenciales en un espacio maker utilizando el ABP, que permitieron la aplicación de los contenidos en proyectos de interés para los alumnos, fijando los contenidos impartidos.*

***PALABRAS CLAVE**: Aprendizaje basado en proyectos. Cultura maker. Formación inicial y continua.*

Introduction

The traditional role of the school, characterized by lesson planning, passing on content to students, assessments and assigning grades is gradually being transformed (BACICH; MORAN, 2018). This transformation consists of the adoption of new teaching and learning methodologies that propose the decentralization of the teacher as a teaching agent and the possibility for the student to be the protagonist of his knowledge (CRUZ; BREMGARTNER, 2021).

The Learning Pyramid theory states that people generally learn more by active learning methods, that is, when they discuss, practice, or teach (GLASSER, 1998). This theory by Glasser (1998) confirms the importance of applying teaching methodologies that

provide students with the practice of what they are learning, proving to be more effective for learning by doing.

This category of methodologies that propose the practice of content is known as active methodologies. These methodologies are teaching strategies that focus on the effective participation of the student in the construction of the learning process, in a flexible, interconnected, and hybrid way (BACICH; MORAN, 2018). Among the active learning methodologies, there is Project-Based Learning (PBL), which consists of allowing students to confront real-world issues and problems that they consider significant, determining how to address them and then acting cooperatively in search of solutions (BENDER, 2014).

A movement that uses PBL and has been gaining space in the international and Brazilian school scene is the movement known as Maker Culture, Do-It-Yourself (DIY) or "hands-on education". Maker Culture consists of creating and modifying objects or projects. Its main pillar is the idea that anyone can make, build, repair, and alter objects of the most varied types and functions with their own hands, with collaboration and transmission of information between groups and people using one or several resources (MARINI, 2019).

Moreover, along with the need for the democratization of technology, the increasing technological advancement has caused a growing demand for professionals who possess greater skills in specific technical areas that can be measured (hard skills). To supply this demand, the curricular training role played by technical and undergraduate courses is extremely important. In this sense, there has also been a concern to promote in students coming from basic education a greater interest in careers in these areas, aiming to meet the needs of the world of work (SANTOS *et al.*, 2019), contributing to the development of each region of Brazil. Thus, one of the challenges of the contemporary school is to learn to deal with technology and turn it into an ally of education (SILVA; BLIKSTEIN, 2020).

Considering the context above, the Federal Institute of Amazonas (IFAM), through the Aranouá Project, in partnership with Samsung da Amazônia (SEDA), has been conducting specialized professional training courses, concomitant and complementary to its regular courses in the areas of Technologies and Engineering, with the purpose of leveraging the academic efficiency of the educational institution itself and supplying the national market with qualified labor, aiming at training students from undergraduate courses in these areas, as well as professionals who work in software development and would like to keep up to date with contemporary content. Besides training, the project also aims at training for immediate start-up in activities related to the world of work. This training seeks to minimize the time required to qualify the trained professional to join companies and start their activities fully.

Thus, we offer 2 Initial and Continued Training courses (ICT) for undergraduate students of Control and Automation Engineering at IFAM, Campus Manaus, Industrial District (IFAM CMDI), which are Development of People and Ideas with Maker Culture and Development of Applied Projects with Maker Culture. These 2 courses were adapted to the hybrid context (a remote part and some face-to-face classes in maker space), due to the Covid-19 pandemic, where vocational courses in this area, as well as in others, have been affected by the imposition of social distancing (FERNANDES *et al*., 2021). Moreover, the 2 courses used as active methodology for the development of the activities an integration of Project-Based Learning with Maker Culture. In addition to 1 teacher, the courses had 2 tutors.

Therefore, this article presents an experience report of 2 Initial and Continuing Training (ICT) courses that involve the Maker Culture, occurred by Projeto Aranouá at IFAM, Campus Manaus, Industrial District (CMDI). Activities involving the execution of projects and the development of artifacts mediated by support tools occurred during the courses. Additionally, the students evaluated their perception of the 2 ICT courses and the process adopted mediated by the technologies involved. With this experience report, we hope to provide information about the strengths and what needs to be changed so that teachers interested in replicating this experience can have a better use of it in similar contexts.

Maker Culture and Project-Based Learning (PBL)

The Maker Culture is already inside some classrooms, in makerspaces, as well as in large companies, or even in the garage of homes, making the logic of "do-it-yourself" a technological and collective event, where the learning-by-doing process occurs, a term coined by John Dewey (2010).

More than a personalized environment, the makerspaces for "hands-on" learning are suitable to stimulate creativity through the application of interdisciplinary activities and projects with the use of technology, such as a portable weather station with Arduino (MELO; BREMGARTNER; SOUZA, 2020), fundamental items for the development of skills that will be part of the students' personal and professional future. It is a place of creations, experimentation, and sharing of discoveries, in which students appear as the protagonists in solving problems, mostly based on situations of our daily lives. A maker space can very well be created starting with scissors and a piece of paper, going up step by step until it reaches dynamics of electronics, programming, coding, Educational Robotics (ER) and the use of tools such as 3D printers, laser cutters or even programmable embroidery machines. The idea

is to integrate tactile practices with audiovisual technologies and software. Such technologies and approaches meet the courses offered by the Federal Education Network, as well as the current needs of the world of work and the reality of the culture of each state in Brazil.

However, Maker Culture by itself does not achieve its goals if it is not within a more consistent learning methodology, as in the case of this proposal, in which we use the Project-Based Learning (PBL) method. When applied together with PBL, Maker Culture encourages teamwork, collaboration, planning, research, decision-making processes, as well as interaction among peers in a lively atmosphere, which allows conflict management and respect for different ideas and opinions, but in search of a common result.

In this way, students, together with their advisors, can use their maker spaces to develop their project in the area they see fit. The dynamics of PBL with Maker Culture creates several contextualizations of maker projects, which lead the student to have a greater involvement, making learning an easier and fun process at the same time.

PBL is a method that organizes learning around projects, involving students in constructive research in which the investigation is a process directed towards a concrete objective that involves research, knowledge construction, and the solution of the proposed challenge. ABP is developed from collective work in a perspective of autonomy and collaboration. The centrality of the entire process lies with the students, not the teacher, who leads and plans the learning situations, but the action in search of knowledge is carried out exclusively by the students.

From this perspective, every project must be initiated by a problem to be solved or a challenge to be overcome by the students (BENDER, 2014), the latter being more common in Maker Culture. Students have autonomy in choosing the solution, their group's project, and the methods to develop it. The process of construction and execution of the project is carried out under the supervision of the teacher and in periodic meetings, based on the planning and construction of a schedule of steps to be completed.

The school contents emerge through the stages of the project carried out by the students and the teacher's guidance used to complement contents and answer questions. Generally, the projects culminate in the elaboration of some prototype or process representing the solution found to the problem or challenge.

Although the Maker Culture facilitates the use of PBL, its use is not a guarantee of a positive result for all involved. This may occur due to the difference in previous teaching-learning methods, making it difficult for some to adapt to a self-directed and collaborative learning environment. Most students come from educational models that promote passive

reception of knowledge and are used to relying on the teacher as the source of fixed and definitive theoretical concepts. In addition, being the traditional teaching method and of common use in teaching practice in Brazil, it is also a challenge for teachers to develop and apply PBL in actions that promote autonomy, group research, and generate an investigative learning environment.

The Execution of ICT Courses in Maker Culture

The two ICT courses in Maker Culture (Development of People and Ideas with Maker Culture, followed by Development of Applied Projects with Maker Culture) took place at the IFAM CMDI. These courses aimed to provide an overview of Maker Culture, allowing the development of people and ideas through tools for project execution, using PBL. Each course was 40 hours long, held on Saturdays during 14 weeks, from September to December 2021, with an average workload of 6 hours per day on each Saturday.

In the first course, Development of People and Ideas with Maker Culture, a total of 4 distinct activities/dynamics were applied, as follows:

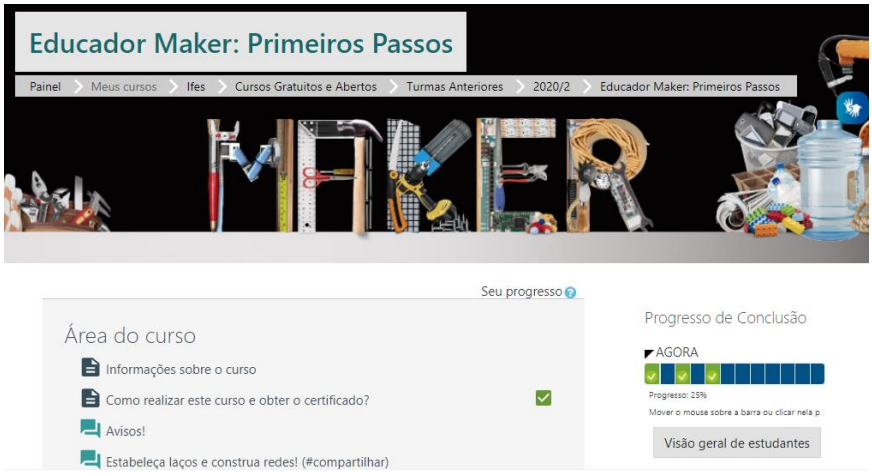
(1) Initial Course Exposition: On the first Saturday of the first course, the program content was presented according to the course outline. The menu consisted of: Introduction to Maker Culture; Spaces that inspire; Maker Mentality; Maker Culture in Education and Project-Based Learning; Sharing Maker Ideas in the World: Presentation of Maker Proposals to be developed. The importance and impact of these concepts in Control and Automation Engineering was explained. The initial class was run using the Google Meet video conferencing platform. This initial class was recorded and made available in a folder shared with the students on Google Drive and Google Classroom.

(2) Training for the Educator Maker Course: In the very first class, the online minicourse Educator Maker: First Steps was presented to be taken by the students. This minicourse is available on the Open Courses Environment of the Federal Institute of Espírito Santo (Ifes) [5]and was developed by professors and students from Ifes and IFAM. As methodology, the minicourse includes moments of individual studies and activities based on self-instruction, such as directed studies, online quizzes and games. We also used moments with activities that lead the students to reflect individually about their praxis, as well as practical activities in collective space and with the sharing of experiences related to the Maker Culture. The contents can be studied freely by the students and are available through videos,

[5] Available at: https://mooc.cefor.ifes.edu.br/. Access on: 12 Oct. 2021.

tutorials, and supplementary material (links, videos, and texts considered relevant). The students have at their disposal a collaborative forum space to exchange information and collaborate in case of doubts. In this sharing space, students can learn from each other, actively collaborating in the construction of their own knowledge and that of the group. In addition, the minicourse has no mentoring, has a workload of 30 hours, is in Portuguese, and has no prerequisites. Figure 1 shows the screen of the course Maker Educator: First Steps.

Figure 1 – Maker Educator Course: First Steps

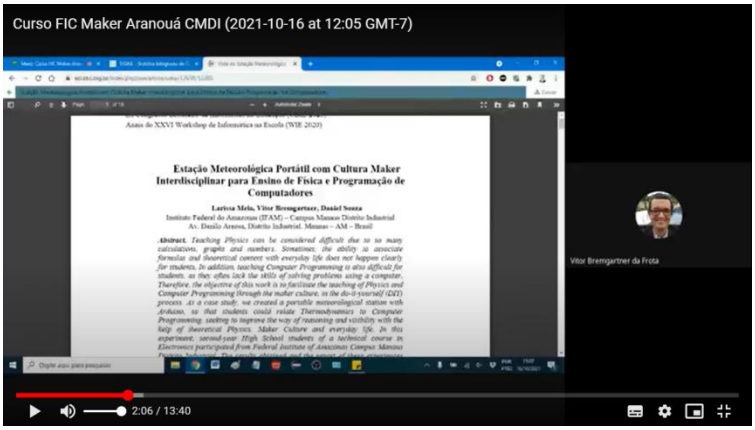


Source: IFES[6] website

(3) Synchronous Weekly Meetings: From the second to the seventh Saturday (end of the first course), weekly meetings were held via Google Meet with the students, who were divided into 11 teams of up to 4 students (some preferred to work individually on their projects) in order to present a proposal for a maker project aimed at solving an everyday problem. The meetings lasted about 10 minutes at most for each team, one at a time, where they discussed the proposals of each team, what the students would try to solve, what materials they would need, besides having a follow-up of the proposals in order to encourage interaction between the students and the teacher. Figure 2 shows a moment when the professor of the discipline is presenting an example of a published article involving a project based on Maker Culture, teaching the students about the writing process of a scientific article. Last Saturday, each team finally made a defense of the proposed Maker project, to be executed in the following course.

[6] Available at: https://mooc.cefor.ifes.edu.br/moodle/enrol/index.php?id=55. Access on: 12 Oct. 2021.

Figure 2 – Using Google Meet for synchronous meetings



Source: Prepared by the authors

(4) Writing the proposal of the maker project in scientific paper format: As a final delivery of this first course, each team should deliver its proposal of maker project in scientific paper format, following the model of articles of the Brazilian Computer Society (SBC). The delivery of the article, as well as the defense of the proposal, should be done on the last Saturday of the first course by each team. After delivery, the teams' texts were reviewed, as well as discussions between the professor and each of the teams occurred so that each proposal could be adjusted, seeking a better quality in the projects to be developed.

After the first course, we started the course Development of Applied Projects with Maker Culture, which consisted in the students learning how to use the tools, as well as the development of the maker project according to the proposal made in the previous course and the delivery of the article about the project now developed. Among the tools used by the students are 3D printers (for additive manufacturing), a Computer Numerical Control (CNC) laser cutting machine, tool sets, drones, Virtual Reality glasses, Arduino kits, soldering station, and electronic components. Using the hybrid teaching format with semi-attendance classes, the practical and attendance part of the course was carried out in the CMDI MAKER Rivelino space, with the proper security measures due to the Covid-19 pandemic. We chose this space because it had resources for the on-site course, such as 3D printing equipment, laser cutters, among others. The teams accessed the maker space at different shifts and times in order to avoid crowding. Rarely were more than 3 teams present in the same space at the same time. Figure 3 shows a training in 3D printing, as well as students developing projects in the CMDI MAKER space. The printer used was the Ender 3, from Creality.

Figure 3 – 3D printing training and students developing projects in CMDI MAKER

Source: Prepared by the authors

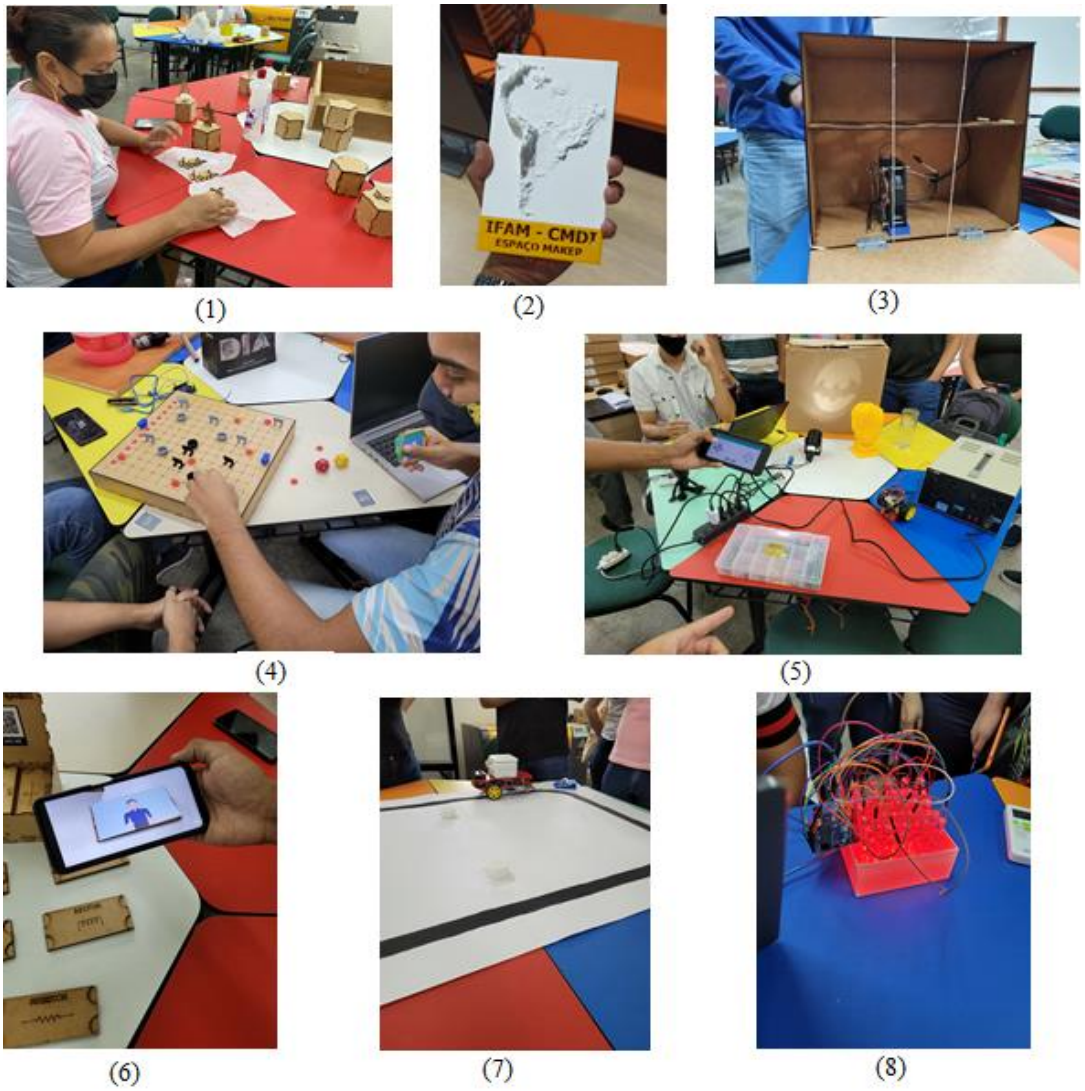
The application of the training activities and the execution of the project were made aiming to have a balance between theory and practice, besides the use of methodologies different from the traditional ones. The results of the project, presented below, demonstrate that this was an option with great potential in the formation of students in Maker Culture.

Results obtained

Throughout the 14 weeks, the students worked in teams, developing their maker project proposals, as well as developing the project and writing a scientific paper about the project developed. They learned how to solve complex problems and to search for specific knowledge, as well as the handling of tools to meet the needs of each work.

Last Saturday, the students presented their developed projects, shown and listed in Figure 4. Among them are: (1) results of an extension minicourse on CNC cutting for women and its social implications (project called IFMARIAS); (2) 3D printed artifacts, such as a relief map of South America; (3) a prototype chicken egg incubator with Arduino; (4) a board game to support the teaching of programming via unplugged computing, with the pieces made of CNC cut MDF and 3D printing; (5) applications involving Internet of Things, with Internet connections to activate projected LEDs and move a trolley by cell phone; (6) an application with augmented reality to help deaf and hearing impaired people in maker experiments in Brazilian Sign Language (LIBRAS), as well as to present the electronic components in this language; (7) a line-following waiter robot made in Arduino, where in this case, it served chocolates to people; (8) an LED cube with light effects in Arduino.

Figure 4 – Projects developed by students at the end of the Maker Culture ICT courses



Source: Prepared by the authors

At the end of the courses, the students voluntarily answered a questionnaire to evaluate their perception of the hybrid teaching experience in the context of these two FIC courses. All 36 students participating in the two courses answered the questionnaire. The students in the class were studying Control and Automation Engineering at the IFAM CMDI.

There were 5 objective and 2 discursive questions. The 5 objective questions with a summary of the students' answers on a Likert scale are shown in Table 1 (SD = Strongly Disagree, PD = Partially Disagree, N = Neutral, PA = Partially Agree, SA = Strongly Agree,).

Table 1 – Answers to the maker course students' objective questions

Were you satisfied with the course?	SD	PD	N	PA	SA
Number of answers	0	0	1	2	33
Was the course relevant and useful for your field?	SD	PD	N	PA	SA
Number of answers	0	0	1	3	32
Regarding the lecture classes	SD	PD	N	PA	SA
The content was covered in a clear and precise manner	0	2	1	6	27
The experience was relevant to my learning	0	2	1	4	29
I believe that the content is up to date	0	0	3	5	28
The activities enabled interaction among the participants	0	1	4	3	28
During the activity, challenges were proposed	0	2	1	6	27
I received feedback from the activities performed	0	1	3	5	27
I would like to have other experiences with this type of activity	0	1	4	3	28
Regarding the Course Design, by the Project-Based Learning methodology	SD	PD	N	PA	SA
The content was covered in a clear and precise manner	0	2	2	7	25
The experience was relevant to my learning	0	1	2	4	29
I believe that the content is up to date	0	1	3	4	28
The activities enabled interaction among the participants	0	1	4	3	28
During the activity, challenges were proposed	0	1	2	3	30
I received feedback from the activities performed	0	1	2	4	29
I would like to have other experiences with this type of activity	0	2	3	2	29
Regarding the writing of the scientific article	SD	PD	N	PA	SA
The content was covered in a clear and precise manner	0	1	5	10	20
The experience was relevant to my learning	0	2	1	5	28
I believe that the content is up to date	0	1	3	6	26
The activities enabled interaction among the participants	0	2	3	6	25
During the activity, challenges were proposed	1	2	4	6	23
I received feedback from the activities performed	0	2	5	7	22
I would like to have other experiences with this type of activity	0	3	1	5	27

Source: Prepared by the authors

In general, according to the answers of the students shown in Table 1, we obtained positive perceptions about the maker courses, even in relation to the writing of the scientific paper (although fewer positive evaluations), since this class had students from the 2nd to the 8th period of Control and Automation Engineering, i.e., heterogeneous as to the maturity of writing a scientific paper, an item that some students seemed to show greater difficulty in doing.

In turn, the 2 discursive questions were made available for the students to describe their impressions about the courses. The following are the main points raised by the students for each discursive question, quoting the students' own speech.

In the question "*What were the most important points of the course*?", the main answers were, separated by semicolons:

"Availability of resources and presence/availability of the Advisor for questions and support throughout the process"; "CNC class, meetings to discuss strengths of the project between the participants and the teacher."; "Learning by doing, having to discover different ways to deal with problems"; "Having a space to develop the project, with the help of CNC

machines, 3D printers, among other tools."; "The dynamics of making a project, thinking of something that could be useful in some way. And the teamwork"; "The availability of a place, components and tools for the development of projects, without much bureaucracy"; "The possibility of learning by doing, we were given enough freedom to create our projects and support so we could get them off the paper"; "The course provided material to create something from scratch, the learning was in practice, I found it very fun and learned a lot of new things, there was a fair to display the final work, and the preparation of an article to talk about the work process"; "Get out of the comfort zone".

In the question: "*Room for suggestions, praise or criticism regarding the course*", the main answers were, separated by semicolons:

"I really enjoyed the course, I believe that the equipment present in the Maker lab provides a broad view of possible projects that can be realized"; "My compliments to the teachers who provided materials for the work process and moreover, giving feedback and even new ideas for the improvement of the article"; "The course as a whole was interesting, however I believe that the main subject, being the maker culture in education, was not exactly exciting or very relevant in general. "The subject itself is very important in education, but the knowledge of its practices for students is not that important, in my opinion"; "For teachers or students who want to become teachers right after graduation I think it is of great importance, but for students who had other professional goals right after graduation it was not extremely necessary"; "It is necessary a standardization for the use and organization of the tools and the place (Maker Space). For this it is necessary the presence of monitors (responsible for the Maker Space), and that can be present on days and times that the Space is used, in order to preserve its integrity. Besides that, they must have the necessary knowledge to guide students in the use of the tools"; "As for the Maker Space there could be more courses demonstrating about other equipment on the site"; "Improvement in the course period, needed more time for the projects take more personality"; "The course was great the way it was, I acquired knowledge and had an improvement as a professional in the electronics area, so it's great"; "Very good commitment and result by all the teaching team, I hope to have more courses like this"; "The course was great the way it was, I acquired knowledge and had an improvement as a professional in the electronics area, so it's great"; "Very good commitment and result by all the teaching team, I hope to have more courses like this".

We can see from the answers to the discursive questions that the course was well received by the students, although some of them criticized the fact that the theoretical part was too focused on educational issues. In a way, the theoretical part involved pedagogical

aspects, in order for the students to understand maker aspects not only in education, but in professional life as a whole. We believe that some students should have understood this aspect better, but we do not disagree with their answers, since being in a Control and Automation Engineering course, practical activities should be much more emphasized in a maker course. Moreover, the limitations imposed by the Covid-19 pandemic forced us to adopt a hybrid strategy, with fewer practical classes than usual.

Final remarks

Overall, all the educational activities had a positive impact on the learning process in the two ICT courses focused on the Maker Culture, as we can observe by the students' performance, the projects delivered and the surveys regarding the students' opinion and perception. Even with limitations due to the Covid-19 pandemic, where we had to adopt a hybrid strategy for teaching, the results were satisfactory. Using ABP in Maker Culture, extracting the best of each in a positive symbiosis and in a hybrid teaching format, was the great contribution of this work. As for the teacher, we noticed that the resizing of his role as a mediator and advisor and not just a transmitter of knowledge was also a useful strategy to stimulate the students' creativity and their freedom of choices and decisions in their projects, bringing promising results for themselves and for the world of work.

As future work, we intend to reapply this study in future classes, taking into consideration the points to be improved, with a greater emphasis on practical activities, as well as including new methodologies and approaches in the context of hybrid teaching. Furthermore, it is intended to analyze the profile of students before entering into maker courses, aiming to identify how their specificities can be explored in order to enhance their learning in the context of their area of expertise.

ACKNOWLEDGMENTS: Part of the results presented in this work were obtained through PROJECT ARANOUÁ, financed by Samsung Eletrônica da Amazônia Ltda., with resources provided for in Federal Law n. 8,387/1991. We also thank the Pro-Rectory of Extension (PROEX) of IFAM for the support and funding of the IFMARIAs project, contemplated by Public Notice n. 05/2021 PROEX/IFAM.

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How to reference this article

BREMGARTNER, V.; FERNANDES, P.; SOUSA, J.; SOUZA, J. C. Project-based learning applied to initial and continuing training courses in the Maker Culture. **Revista Ibero-Americana de Estudos em Educação**, Araraquara, v. 17, n. 3, p. 1942-1956, July/Sept. 2022. e-ISSN: 1982-5587. DOI: https://doi.org/10.21723/riaee.v17i3.16409

Submitted: 02/03/2022
Revisions required: 21/04/2022
Approved: 19/06/2022
Published: 01/07/2022

Processing and publishing by the Editora Ibero-Americana de Educação.
Correction, formatting, standardization and translation.