Journal of Modern Education Review, ISSN 2155-7993, USA
August 2021, Volume 11, No. 8, pp. 814–826
Doi: 10.15341/jmer(2155-7993)/08.11.2021/002

http://www.academicstar.us

Remote Strategies of Activities Based on Maker Culture in Covid-19 Pandemic Times

Denys Cruz, Larissa Melo, Vitor Bremgartner
(Federal Institute of Amazonas, PPGET/IFAM, Sebrae LAB, Manaus, Brazil)

Abstract: This paper presents an experience report about 2 remote strategies based on the active learning methodology known as Maker Culture, in the face of the Covid-19 pandemic scenario. Also, this paper brings some reflections on these experiments, which serve for interested teachers to apply or not (depending on the decision of each teacher) the Maker Culture in their educational context within the most varied disciplines that they can teach, even remotely. To this end, this work uses as a basis the concepts of Maker Culture, also known as hands-on education, developing ideas to be used remotely. Thus, the 2 approaches presented are: online workshop of 3D printer and portable meteorological (or weather) station with Arduino for teaching Physics. The results of tests applied in remote classes are presented. This work also discusses how items from Maker Culture, such as 3D printer and Arduino, can facilitate the teaching of contents that aggregate content to the school curriculum.
Key words: maker culture, remote strategies, Covid-19 pandemic

1. Introduction

The theory of the Learning Pyramid of the American psychiatrist William Glasser shows that people generally learn more by the active learning method, that is, when they discuss, practice or teach (Glasser, 1999). This Glasser Theory confirms the importance of applying active teaching methodologies that provide students with the practice of what they are learning, that is, it is more effective for learning if they learn by practicing. Active learning methodologies are also helping to change the traditional learning environment in schools and this means a gain for both parties, for the school and for the student. The active methodologies, which propose the practice of content, constitute a set of 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). For Ausubel (1963, p. 58) "meaningful learning is the human mechanism, for excellence, to acquire and store the vast amount of ideas and information represented in any field of knowledge".

In this context of active methodologies, a movement known as Maker Culture or "do-it-yourself" (DIY) trend in several countries, including Brazil. Maker Culture consists of creating, modifying objects or projects. Its main

---

Denys Cruz, Postgraduate Student at Postgraduate Program in Technological Education (PPGET), Federal Institute of Amazonas (IFAM), manager of the Innovation and Entrepreneurship Laboratory at Sebrae LAB; research areas: maker culture. E-mail: dncruz@gmail.com.

Larissa Melo, Graduate Student, Federal Institute of Amazonas (IFAM/CMDI); research areas: maker culture and control and automation engineering. E-mail: larissaalencarmelo@gmail.com.

Vitor Bremgartner, Professor at Postgraduate Program in Technological Education (PPGET), Federal Institute of Amazonas (IFAM); research areas: maker culture and informatics in education. E-mail: vitorbref@ifam.edu.br.

pillar is the idea that anyone can manufacture, 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 (Marini, 2019). This relevance that Maker Culture has gained in the international and Brazilian school environments is due to the fact, not that it is the solution to the challenges of education, but to the fact that it is based on concepts of active methodologies, proposing to solve challenges that involve the day-to-day lives of students or their community (Blikstein, 2017).

However, another aspect that has been observed since March 2020 was that with the new reality imposed by the Covid-19 pandemic (World Health Organization, 2020), such as avoiding agglomerations, the students, not only in Brazil, needed have greater autonomy in their learning. As Maker Culture is based on autonomy in the process of creation and learning, but at the same time in activities that must be carried out collaboratively, together and in face-to-face contact (Silva & Blisktein, 2020), the following question arises: How to disseminate the Maker Culture, to an audience of different levels of education, but in a distance format? The transmission of information between groups and people, whether in Maker Culture projects and activities or even in the traditional classroom, is undergoing changes due to the new reality imposed by the Covid-19 pandemic, to avoid agglomerations and to comply with the other recommendations suggested by World Health Organization. Therefore, in this undeniable scenario of rapid change, schools and education, through teachers and students, need to be involved with technologies and their tools, methodological and pedagogical innovations, which have often been the target of resistance.

Before the Covid-19 pandemic, projects and activities based on the Culture Maker, such as the construction of a free platform for access to Educational Robotics and simple solutions using scraps, for example, were mostly developed in groups and in person. Now with the Covid-19 pandemic, Maker Culture, as already said, needed to change its format, but without losing its relevance, thus gaining a new challenge: to remain relevant in remote format, even if there is little material in remote format for its implementation. Even so, remote maker strategies may be useful not only in the face of this atypical situation in the Covid-19 pandemic, but in others where remote Maker Culture needs to be worked on, such as students unable to be present in the classroom due to issues lack of security in the city, for example. Thus, this work aims to show a reflection from examples of activities related to Culture Maker remotely, through an online 3D printing workshop and an experience involving Physics, with its advantages and difficulties encountered.

2. Theory Background

2.1 Maker Culture as an Ally in the Teaching-Learning Process

Dale Dougherty, who helped promote the term Maker, launched a magazine in 2005 in the USA, entitled as Maker, and the following year, in 2006, held Maker Faire, the first Maker Fair, which has consolidated itself as an annual maker event, bringing together people from different parts of the world. For Dougherty (2012), Culture Maker should not be considered as a new Industrial Revolution, but as a Renaissance movement, because it uses tools to shape society and the future.

The exponential growth of technology and the availability of new technologies are part of the main driving factors and advancement of Maker Culture (Dougherty, 2012). In addition, 3D printers, milling machines, automation kits such as the Arduino platform, and other equipment that allow the creation or modification of products, have become more accessible for purchase, thus promoting an expansion of educational activities. Other factors, according to Blikstein (2017), helped to increase the acceptance of Maker Culture, such as the increase in economic competitiveness based on innovation between different countries.

The maker activities are based on the Constructionist approach (Papert, 1980), which highlights the gains that the student has when he participates in projects, that provide his protagonism and encourage his creativity through results for real problems. The DIY culture brings the idea of reusing objects, instead of disposing and acquiring new ones. In this type of educational practice, there is a proposal for a change of vision about what it means to have something, and about the consumption habits inserted in the current system in which we live.

Maker Culture is already inside some classrooms, as well as in large companies, or even in the garage of houses, making the logic of DIY a technological and collective event (Hirabahasi et al., 2015). When we work with Maker Culture, it allows the student to be the protagonist in the construction of their knowledge based on practical learning. Thus, in some schools (or outside of them) there are already laboratories for the practice of Maker Culture, known as Makerspaces or Fab Labs. In these environments, activities seek to develop creativity, autonomy and collaboration, in most cases through projects and prototype development.

This work intends to contribute to the dissemination of Maker Culture, so that people, regardless of school age or level of education, have the possibility of free access, even remotely, to workshops and related activities.

2.2 Remote Teaching in Pandemic Times of Covid-19

The distance and social isolation imposed by combating the spread of Covid-19 forced changes in the traditional way of teaching, where sudden changes occurred in several aspects of the school routine. In the Education area, the main change was the transition from face-to-face teaching to remote classes or to distance classes (Silvaand Blisktein, 2020). However, this process was not homogeneous, that is, it was not all schools, nor the majority of them, that can make this transition or adaptation.

This change also did not occur quickly, in a country like Brazil where inequality in access to education is profound and abysmal. This change was extremely slow, and in some schools it didn't even happen. The ideal for children and young people from less favored economic classes to have the least possible impact on their school development and the school timetable was not compromised, would be to take teaching remotely into the homes of these low-income students — including with guidance financing and standardization of the Brazilian Ministry of Education. However, for remote teaching to happen it is essential to adopt different technologies, allowing students to communicate, interact and evaluate, even though they are away from school.

Unlike traditional distance learning, remote education advocates the real-time transmission of classes. The idea is that teachers and students in a class have interactions at the same times as the discipline's classes would take place in the face-to-face model. That is, in remote education, the classroom routine is maintained in a virtual environment accessed by each one, from different locations.

According to a bibliographic survey, there are works in the literature that describe activities with remote teaching during Covid-19 pandemic. Portal et al. (2020) shows the change in the performance of higher education students during the coronavirus crisis through the use of flipped learning. The authors compared the results obtained by the students on whom the flipped learning methodology was scheduled to be applied with the students on whom the same methodology had been applied, albeit under normal circumstances. To carry out this study, they compared the following variables among the two courses: class attendance in face-to-face classes against online classes, the index of those who appeared for the final exam of the subject (in person in 2019 and online in 2020) and the results. The results depicted that after applying the same flipped learning methodology in both courses, the performance of the students in the current period, whose classes and tutoring have been carried out completely online, was superior. Another related work is presented by Guerola-Navarro et al. (2020), in which the objective of his present study was to evaluate the satisfaction of the students with the methodology of Project-Based Learning (PBL), applied in the teaching of the subject “Organizational Behavior and Management of Change”, in an unknown environment such as that of the passing of face-to-face classes to telematics classes in the middle of the school calendar, and due to an unexpected and unforeseen situation such as that derived from the confinement imposed to fight the global health pandemic of Covid-19. The students agreed that PBL was a useful strategy to be applied in these pandemic moments. The results confirm that PBL is an effective and more efficient methodology if possible, in these circumstances.

Our work makes it possible to contribute to those found in the literature by assessing students’ perceptions of maker experiments remotely. In addition, in the face of the Covid-19 pandemic, another differential in our work was obtaining experiences that contribute to remote teaching-learning practices. Thus, this research intends to reflect on the lived experiences that serve as contributions to remote teaching-learning practices in the Maker Culture.

3. Remote Maker Applications

3.1 Application 1: 3D Printing Workshop

In order to promote Maker Culture, we have developed an online 3D printing workshop for anyone who wants to know how a 3D printer works and how to use it. For this, the planning and recording of 4 videos was carried out at the Federal Institute of Amazonas/Campus Manaus Distrito Industrial (IFAM/CMDI), covering the following topics: theory and software; printer assembly; leveling and removing the printed part. In addition to the 4 videos produced, a questionnaire was developed and applied to assess learning about some technical concepts of 3D printing and to evaluate other aspects of the offered workshop. It is important to emphasize that 3D printers are today essential tools for the practice of maker activities, as they provide the prototyping of a product, allowing the student to be the creator of his product, making him the protagonist of his learning.

In this way, a remote 3D printing workshop of earmuffs was developed and applied initially to be used in masks against Covid-19, where the students participating in the workshop answered a questionnaire that contained open and closed questions. Therefore, quantitative and qualitative data were generated, with analysis and interpretation of these data. The experimental online workshop was aimed at students of an IFAM/CMDI extension project and other people interested in the topic, all of them from different educational levels (Higher, High, Elementary). The objective of the experiment was to investigate how an online 3D printing workshop could help in the process of immersing people interested in Maker Culture, specifically 3D printing. The following steps were taken: a) Planning of the methodology; b) Recording of videos and availability of handouts; c) Conducting a survey using an electronic questionnaire with the students, in order to obtain their level of satisfaction and assess whether the students had any gain in knowledge regarding the applied course.

The 3D printer used in this online workshop was the Ender 3 model from the company Creality, as shown in Figure 1. This specific model has the printing surface heating, which can reach 90 degrees Celsius and its panel control system, with which the entire print configuration can be made.

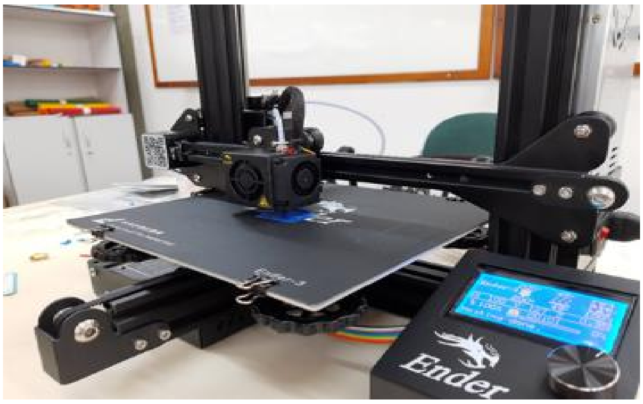

Figure 1 Ender 3 3D Printer

The workshop was recorded in the Maker Lab of IFAM/CMDI (Figure 2) and later made available on the YouTube platform. This maker space was intended for Technical and Higher Education, with the purpose of expanding the practices of Maker Culture to participating students.

Figure 2 3D Printing Course Being Recorded at the Maker Lab at IFAM/CMDI

The purpose of the videos was to teach how the application of 3D printing techniques in the educational context can be associated with problem solving. On the occasion, students received information on how to use 3D printing in the face of the problem that permeates society in this current pandemic moment: the Covid-19 pandemic and the importance of Personal Protective Equipment (PPE) aimed at doctors and nurses. Along with this, a YouTube channel was used to transmit the information. In Figure 3, below, the completed impression of the PPE, an ear protector for masks, is shown. In Figure 4, the test of the protector with a mask is demonstrated, verifying the adaptability and flexibility of the part in practice.

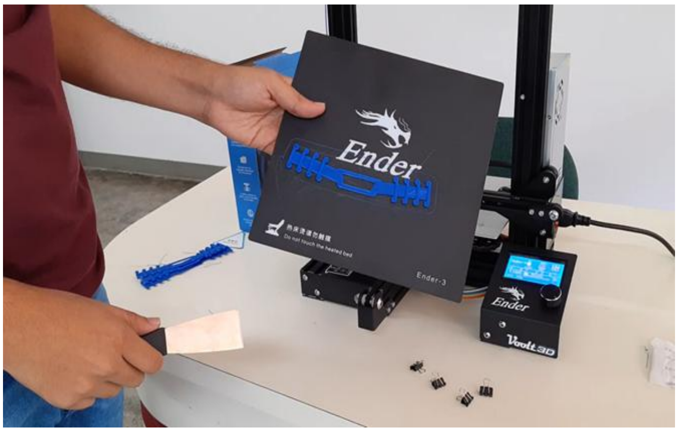

Figure 3   Ear Protector

Figure 4   Use of the Ear Protector With the Mask

We made a quali-quantitative assessment of the approach used. In this research, a survey design was used, characterized by the direct questioning of the participants, after the completion of the activities. It was applied after attending classes and after reading the suggested 3D printing training booklet. We applied a questionnaire to record the students' point of view regarding the subjects and evaluate the level of information capture. In the development of this questionnaire, topics that were related to the experiment were addressed. The questionnaire, shown below, was made available through the Google Forms tool and contains 14 questions. They are:

1st: What is your level of education? (   ) Elementary (   ) High School (   ) Higher Education (   ) Others
2nd: Are you: (   ) Teacher? (   ) Technician?(   ) Student? (   ) Others
3rd: If you belong to an institution, indicate which one. If none, type None.
4th: What is your level of experience with 3D printing before the workshop?
(   ) None (   ) Little (   ) Moderate (   ) Quite
5th: What is the ideal final temperature for preheating the PLA in the bed and in the extruder?
6th: What is the function of a 3D slicer?
7th: What is PLA and what are its characteristics?
8th: On a scale of 0 to 10, what are the possibilities of recommending this workshop to a friend or colleague?
9th: In a scale from 0 to 5, how do you evaluate the quality of the videos?
10th: Did the information help you to understand more about 3d printing? (   ) Yes (   ) No
11th: What was most interesting about this training?

12th: What was most difficult about this training?
13th: After this training, what is your level of interest in the 3D printing universe?
() I am more interested and I want to have the opportunity to practice in person, as soon as possible
() I liked the subject, but I do not intend to delve into the theme
() I did not like the subject and I do not intend to delve into the subject
14th: Additional comments (suggestions, compliments, doubts) about our workshop.

Next, in Table 1, are the answers and the percentage of error and success rates for each question. The questions were asked to be answered in an objective and subjective way, so that the participant had the opportunity to present their ideas and opinions. To check the rates of errors (wrong answers, unanswered and that the participants did not know) and correct answers, sequential tables were set up, divided into introduction, knowledge and evaluative questions.

Table 1 Level of Training and Experience With the Theme

Q1: What is your level of education?	Q2: Are you:	Q3: If you belong to an institution, indicate which one. If none, type None.	Q4: What is your level of experience with 3D printing before the workshop?
44% High School	92% Students	92% IFAM	84% No Experience
40% Technical Level	8% Others	4% Private Universities	12% Little Experience
16% Others		4% None	4% Moderate Experience

The first sequence of questions (Table 1) was made to the universe of 26 participants in order to find out the current training levels, entities to which the participants belong and the level of knowledge about the 3D printing theme. Among the numbers, we can highlight a high participation of students from IFAM, in the percentage of 92%, the majority of which 84% have no experience with the use of 3D printer.

In Table 2, there are answers related to questions about extrusion temperature, use of slicing software and characteristics of printing inputs. There were a number of correct answers above 80%, allowing us to conclude that they were able to capture the information passed on during the application.

Table 2 Rate of Correct Answers/Errors of the Participants

	Q5: What is the ideal final temperature for preheating the PLA in the bed and in the extruder?	Q6: What does a 3D slicer do?	Q7: What is PLA and what are its characteristics?
Hit rates	82.4%	87.1%	87.1%
Error rates	17.6%	12.9%	12.9%

Next, according to the data in Tables 3 and 4, below, it is possible to verify that there was a level of acceptance in relation to the content presented, as well as a high understanding of the information passed on, from the point of view of the respondents.

Table 3 Impressions of the Participants

Q8: On a scale of 0 to 10, what are the possibilities of recommending this training to a friend or colleague?	Q9: On a scale of 0 to 5, how do you rate the quality of the videos?	Q10: Did the information help you understand more about 3D printing?	Q11: What was most interesting about this training?
56% recommended level 10	72% rated level 5	96% YES	90% Practicality and the possibility of getting to know the 3D printer
40% recommended between levels 7, 8 and 9	20% rated it at level 4	4% answered NO	5% Part of the theory
4% recommended at level 1	8% rated at level 3 or 2		5% The entire training

Table 4 Participants' Level of Interest

	Q12: What was most difficult about this training?	Q13: After this training, what is your level of interest in the 3D printing universe?	Q14: Additional comments (suggestions, compliments, doubts) for our workshop?
Frequently asked answers	Installation and assembly procedures	80% are more interested in this topic	Questions related to using the software before printing

In the view of Silveira (2016, p. 116) the "hands-on" provided by the Maker movement helps students to adopt creative and proactive postures, generating a mental model that helps for solving everyday problems. In this way, the 3D printer association ensured that students not only acquired theoretical knowledge, but applied it to solve problems. In this case, hands-on, that is, the practical part, with students was unable to be held due to the fact that the course takes place during the pandemic period and the students do not have a 3D printer in their homes, even though having this equipment does not be a common thing.

3.2 Application 2: Portable Meteorological (or Weather) Station for Teaching Physics

Our second application is to use Maker Culture remotely to assist in the teaching of Physics. We assume that the teaching-learning process of Physics has to be appreciable for students, so that they can understand and visualize that Science and Technology are present in everyday life everywhere and that constantly change (Melo, Bremgartner & Souza, 2020). When teaching Physics, it is possible to awaken the investigative and critical reasoning of each student, but this is possible if there are changes in the way of teaching (Vidal, 2018). In the view of Dewey (2003), redesigned for the modern situation of creative, globalized and accessible teaching, there is no lack of experience in the classroom, but yes, there is no need to leave the classroom and have real and connected experiences. This lack of pedagogical intent in experimentation generates a lack of focus, dispersion and discontent along the path of teaching. Still, the occasional experience without concrete pedagogical intention, without clear objectives, can generate frustrating and dispersed results, in an exodic effect, as it does not establish a connection with the next experiences, becoming pure distraction or entertainment (Dewey, 2003; Resnick, 2017).

Therefore, this second experiment aimed to facilitate the teaching of Physics, having as a case study applications of the concept of Thermodynamics, through the Maker Culture with Arduino for the construction of a portable meteorological (also called weather) station. In this way, we hope that the Physics classes are not only in the instructional model, which consists only of a transmission of knowledge, but is based on the constructionism of Seymour Papert (1980), where the student creates and builds through exploration and discovery, having the teacher as a mediator (Cambruzzi et al., 2015). Furthermore, the use of the computer in teaching and learning Physics reduces the technological distance between students and schools, functioning as a laboratory instrument.

In this maker approach, we usedArduino (Arduino, 2020), which is an open-source prototyping platform, with software that is flexible and easy to use. With Arduino it is possible to create the most varied projects, interactive environments, being able to interact with lights, clothes, engines, electronic objects, among others. It is aimed at artists, designers, hobbyists and anyone interested in creating interactive objects or environments. In this way, the projects that are developed with the Arduino can be autonomous or communicate with a computer to perform a certain task.

To perform this experiment, we select the necessary materials. We used the Arduino Uno model connected to a protoboard in the electrical scheme shown in Figure 5. Then, the Meteorological Station was assembled and the codes were developed on the Arduino platform in C language. To elaborate the initial circuit that was used in the prototype in question, the assembly scheme shown in Figure 1 was obeyed (we simulated this assembly in the Fritzing software) and for this, the following components were necessary: 1 protoboard; Jumpers; 1 potentiometer 10k; 1 LCD display 16 columns x 2 lines; 1 pressure and temperature sensor BMP 180; 19 V battery; 1 briefcase; 1 battery clip.

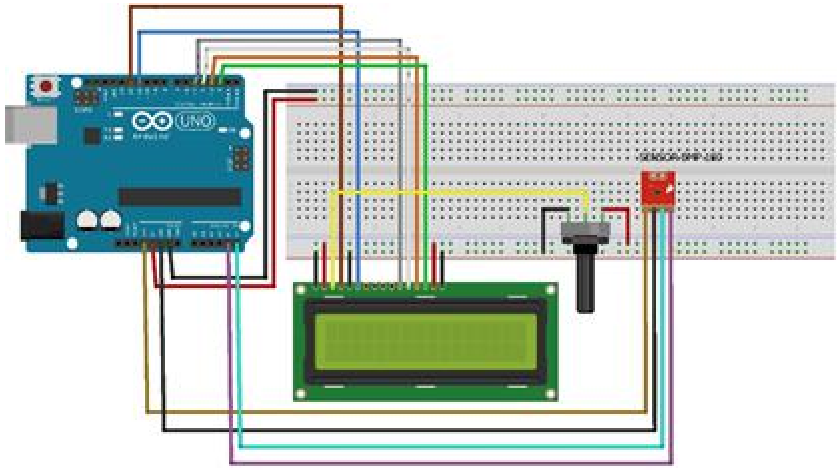

Figure 5 Assembly Diagram Used for the Construction of the Circuit

Source: Melo, Bremgartner & Souza, 2020

After assembling the electronic part, we set up experiments that simulate meteorological measurement equipment: barometer, pluviometer and thermoscope. The materials used for the pluviometer were: PET bottle of 2 liters; Insulating tape; Scale; Dye; Scissors. The materials used for the barometer were: Scissors; Scotch tape; Balloon; Glass; Elastic; Straw; Ruler or graph paper. The materials used for the thermoscope were: Pet bottle; Alcohol; Hose; Scale; Dye.

The relationship of the circuit made on the Arduino platform with these assembled homemade materials occurs through the measurement and measurement of the pressure and temperature values, in order for the students to associate the pressure and temperature variations with the values measured by the sensor in the Arduino. For the assembly of the circuit we used the BMP 180 sensor, which made the measurements of atmospheric pressure and temperature. In addition, we can determine the altitude. The contact pins were also soldered on the 16×2 LCD display, which serves to show the temperature, pressure and altitude values (these two alternated with time to be shown). With all the components soldered and having the C language code to control the weather station, the station's assembly continued. After the assembly of the circuit was completed, it was placed inside a suitcase, so that it can be transported. The complete meteorological station is shown in Figure 6. In the circuit of the physical system of the meteorological station, we used a 170 point mini protoboard that was coupled to a protoshield on the Arduino. These changes were made to make our assembly simpler and easier to transport.

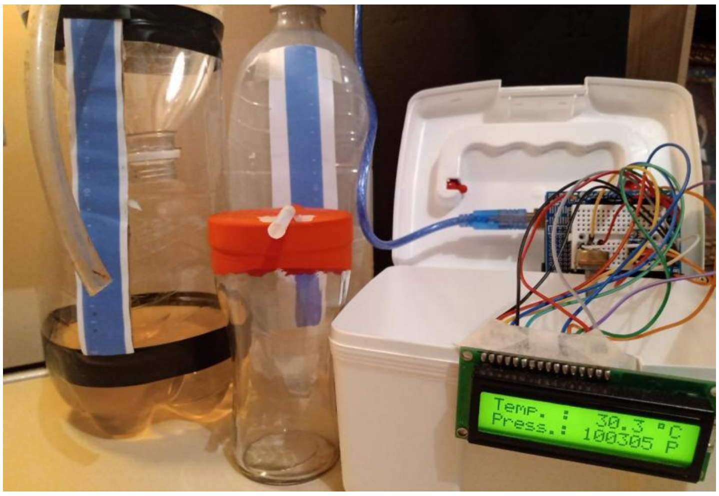

Figure 6 Portable Meteorological Station

Source: Melo, Bremgartner & Souza, 2020

We carried out an experiment with 20 students of the second year of the High School course in Electronics at the Federal Institute of Amazonas Campus Manaus Distrito Industrial (IFAM/CMDI). In the experiment, we wanted to investigate how the Maker Culture combined with the Arduino could facilitate the teaching-learning process of Physics, in a way that helps in learning this subject through the creation of a portable weather station with Arduino. A priori, we would conduct experiments in person, but we had to apply remote experiments due to the Covid-19 pandemic.

All 20 students underwent an initial test regarding concepts of Thermodynamics, consisting of 8 questions, in order to obtain the initial diagnosis of these students. Then, all the students attended an online lesson from the Physics teacher and finally, the students were divided, through a lottery, into 2 groups: the group that participated in the remote maker experiments (10 students) and the group that did not participate (10 students). We applied a final questionnaire to the whole class, in order to find out if there was any acquisition of knowledge of the class regarding the concepts of Thermodynamics in the students who participated in the remote maker experiments, compared to those who did not participate. In total, there were 3 questionnaires: 1 for initial diagnosis, 1 for final and 1 for opinion polls about the maker experiments, the latter being only for the 10 students who participated in the maker experiments.

Initially, we applied the first questionnaire. In developing this questionnaire, we sought to address topics that are related to the experiment. The first questionnaire aimed to verify the previous knowledge that students had about Thermodynamics. The questions were asked to be answered subjectively, so that the student could expose his ideas. In the 8 questions, only 1 question more than 50% of the students got it right. In the other 7, a greater number of students who answered incorrectly prevailed.

Then, after this initial diagnosis, the 10 students who participated in the maker experiment step watched the recorded videos (12 in total), these being: the project script, project components, soldering the components, assembling the station with a protoboard of 800 points, assembly of the station, DIY: Barometer, DIY: Homemade Rain Gauge, DIY: Thermoscope, Maker Instruments, Weather Station Test, Arduino Code: BMP 180, Physics class. All of them were available on YouTube. Students who had the materials at home, including electronic devices and the Arduino, could do the experiments. Those who did not, only accessed videos of the assembly of each instrument and the weather station.

After this stage, only the 10 students selected to participate in the maker experiments answered a survey questionnaire. The questionnaire was made available via Google Forms and had 7 questions related to the installation of the weather station and objective questions of agreement or disagreement in relation to the relevance of the project's application. We conducted an opinion poll based on a questionnaire based on the Technology Acceptance Model (TAM) (Davis, 1989), in order to obtain the level of satisfaction of students regarding the ease and usefulness of our methods employed. Regarding the students' perception of the ease of use of the Arduino portable weather station, 80% of the students partially agreed that it was easy to learn how to create and use the station, 60% of the students agreed that it is easy to remember how to build the station portable meteorology with Arduino for future applications and 70% of the students agreed that it was easy to apply the concepts of Physics seen in the classroom with the use of the meteorological station. Regarding the students' perception of the usefulness of the portable weather station with Arduino, 90% of the students agreed that the weather station allowed them to learn Physics in a better way than if they studied only in theoretical classes, 80% of the students agreed that using the weather station improved their knowledge in the area of Physics, 60% of the students agreed that using the weather station was useful to stimulate interest in the area of automation and also to pursue a career in this area.

Finally, the final questionnaire was aimed at all 20 students in the class, both those who participated in the maker experiments and those who did not participate, so that there could be a comparison with the questions in the first questionnaire and among those who participated and did not participate of the maker experiments. Thus, the last questionnaire has the same number of questions as the initial questionnaire. As a result, there was a significant increase in hit rates (from 50% of students in 4 questions) regarding Physics questions, especially among students who participated in the maker experiments, which confirms the positive results of the application of the weather station for teaching Physics.

Therefore, the application of the project with the use of the Maker Culture for teaching Physics has brought good results, although we believe that these results could have been better if they had occurred in a semi-face-to-face or face-to-face manner or even if all students had Arduino in their homes, to learn by practicing programming in the teaching of Physics, since it is less accessible than the materials for making homemade gauges.

4. Conclusion

This paper presented 2 experiments carried out involving Maker Culture remotely due to the limitations imposed by Covid-19 and some reflections on the activities that took place. The first experiment consisted of developing an online workshop to promote Maker Culture and knowledge about 3D printing, through a solution of an auxiliary product to be used with masks (PPE), an ear protector, so that users, health professionals, do not hurt their ears while wearing masks, during the Covid-19 pandemic in the city of Manaus, Amazonas, Brazil. The production of earmuffs in 3D printing, to be used with the masks and offered free of charge to local health professionals and the production of the online workshop in 3D and its free availability, is a characteristic contribution of Maker Culture, which values sharing of knowledge. The online 3D printing workshop, offered for different levels of education, through the provision of simplified classes in short videos, allowed the participants of the suggested activities to be able to absorb the technical terms, as well as visualize the ways of operating the printing equipment.

Despite the momentary impossibility of students not being able to use the 3D printer due to the Covid-19 pandemic and they do not have it in their homes, we believe that this format can contribute as another learning tool that will enable the development of skills in an interactive way, contributing to the student's effective learning, with regard to 3D printing. The developed workshop was useful for the effective learning of the student who intends to obtain 3D printing concepts and practices, both for IFAM/CMDI students and for students from other Educational Institutions.

Another experiment consisted, from Maker Culture, of a portable meteorological station to provide an interface between the concepts of Physics (in particular, Thermodynamics) obtained in classrooms and the everyday reality for High School students. This was possible with the availability of even more simplified programming tools, such as the Arduino platform, so that teachers and students of Middle and Higher levels can carry out activities involving Algorithms and Programming Language. Taking into account the low cost and ease of handling of the Arduino platform, we believe that this platform can contribute as another learning tool that will enable the development of skills in an interactive way, contributing to the effective learning of students in areas of Professional and Technological Education. The results obtained show that there was great acceptance on the part of the students who used the weather station.

Among the limitations of this second experiment, only 20 students from the entire class of 40 students had guaranteed access to the Internet, being able to participate in remote experiments and being considered for analysis. The Meteorological Station developed was useful for the learning of the student who intends to obtain concepts and practices in Physics, where any educational institution can reproduce the steps and methods presented here, with the adaptations that suit (including in person, when the pandemic will be properly controlled). As future work, we intend to improve the 3D printing course, along with its various applications, as an educational product, as part of a set of learning projects for interdisciplinary maker activities.

Acknowledgements

This paper is a result of the project supported by the Foundation for Research Support of the State ofAmazonas (in Portuguese, Fundação de Amparo à Pesquisa do Estado do Amazonas – FAPEAM), contemplated in Scientific Initiation Support Program (in Portuguese, Programa de Apoio à Iniciação Científica, PAIC).

References

Arduino (2020). *Arduino Uno Rev3*, available online at: https://store.arduino.cc/usa/arduino-uno-rev3.

Ausubel D. (1963). *The Psychology of Meaningful Verbal Learning*, New York: Grune&Stratton.

Bacich L. and Moran J. (2018). *Metodologias Ativas Para Uma Educação Inovadora: Uma Abordagem Teórico-prática* (1st ed.), Porto Alegre: Penso Editora Ltda.

Blikstein P. (2017). *MakerMovement in Education: HistoryandProspects*, in: M. J. de Vries (Ed.), *Handbook of Education*, Springer International Publishing.

Cambruzzi E. and Souza R. M. (2015). *Robótica Educativa na Aprendizagem de Lógica de Programação: Aplicação e Análise*, Anais do *XXI Workshop de Informáticana Escola (WIE)*.

Davis F. (1989). "Perceived usefulness, perceived ease of use, and user acceptance of information technology", *MIS Quarterly*, pp. 319–340.

Dewey J. (2003). *Experience & Education*, Free Press.

Dougherty D. (2012). "The maker movement", *Innovation: Technology, Governance, Globalization*, Vol. 7, No. 3, pp. 11–14.

Glasser William. (1999). *Choice Theory: A New Psychology of Personal Freedom*, Harper Perennial.

Guerola-Navarro V., Oltra-Badenes R. and Gil-Gomez H. (2020). "Global satisfaction within a university subject: Organizational behavior and change management after using project-based learning in times of Covid-19", in: *Proceedings of 13th annual International Conference of Education, Research and Innovation (ICERI2020)*, Sevilla, Spain.

Hirabahasi G. et al. (2020). "Movimento maker", available online at: http://infograficos.estadao.com.br/e/focas/movimento-maker/.

Marini E. (2019). "A expansão da cultura maker nas escolas Brasileiras", *Revista Educação*, available online at: https://revistaeducacao.com.br/2019/02/18/cultura-maker-escolas/.

Melo L. Bremgartner V. and Souza D. (2020). "Using interdisciplinary maker culture with arduino to teach thermodynamics and computer programming", in: *Proceedings of 13th Annual International Conference of Education, Research and Innovation (ICERI2020)*, Sevilla, Spain.

Papert S. (1980). *Mindstorms: Children, Computers and Powerful Ideas*, New York: Basic Books.

Portal M., Manzanares A. and Pagola A. (2020). "The change in the performance of higher education students during the coronavirus crisis: The use of flipped learning", in: *Proceedings of 13th annual International Conference of Education, Research and Innovation (ICERI2020)*, Sevilla, Spain.

Resnick M. (2017). *Lifelong Kindergarten: Cultivating Creativity Through Projects, Passion, Peers, and Play*, MIT Press.

Silva R. and Blisktein P. (2020). *Robótica Educacional: Experiências Inovadoras na Educação Brasileira* (1st ed.), Porto Alegre: Penso Editora Ltda.

Silveira F. (2016). "Design & educação: Novas abordagens", in: Mmegido V. F. (Org.), *A Revolução do Design: Conexões Para o Século XXI*, São Paulo: Editora Gente, pp. 116–131.

Vidal R. (2018). "Ensino de Termodinâmica através da construção de instrumentos de medição de variáveis meteorológicas e da confecção de miniestação meteorológica portátil com Arduino", Dissertação (Mestrado em Ensino de Física) – UFRN, Natal, RN.

World Health Organization (WHO) (2020). *WHO Coronavirus Disease (COVID-19) Dashboard*, a online at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-andanswers-hub/q-a-detail/q-a-coronaviruses.