Contribution Practice Illustration

Title Educational Robotics and Human Emancipation in Youth and Adult Education: Socioconstructivist Research

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Abstract Human emancipation is a relevant characteristic for students in youth and adult education. It enables participants in an educational modality marked by denials to free themselves from tutored and hegemonic thinking. They achieve it through the exercise of awareness and critical thinking. The process of human emancipation of these students can be enhanced using educational robotics when based on a socioconstructivist pedagogical design intertwined with emancipatory principles. By doing it, this article presents partial data from a doctoral research project that addresses this issue and is currently underway. The section presented here discusses issues inherent to the second and third phases of the doctoral research. It aims to announce the characteristics of Design-Based Research that justified its adoption, The article (a) reveals the methodology used in the construction of the socioconstructivist pedagogical design responsible for conducting the iterative cycles of application and improvement of the interventionist action, (b)

presents the design developed, (c) discusses the first iterative cycle carried out and, finally, (d) discusses the partial findings revealed at the end of the first cycle, pointing out the emancipatory principles and indicators investigated that achieved satisfactory success from the application of the design created, as well as those that need attention and will consequently determine the redesign of the solution developed.

Educational Robotics and Human Emancipation in Youth and Adult Education:
Socioconstructivist Research

Társio Ribeiro Cavalcante, Emanuel do Rosário Santos Nonato

1.0 Introduction

Youth and Adult Education (YAE) students of Instituto Federal Baiano – Campus Catu (IF Baiano) belong to a reality marked by poverty. Most of the students have the same bias. In great majority, they are black women with an average age of over 38 years old. Some of them are mothers of families. Some of these black women have studied at public schools. They are likely to be unemployed. It is common for them to be daughters of illiterate parents.

The historical and social context of this reality demarcates a scenario where women are not allowed to have a higher level of education than their partners. It is usual to find narratives where the mere presence of this women at school justifies domestic violence – another unacceptable reason for its perpetuation. These black unemployed women also find hard times returning home, during the night shift. They do not have the right to attend class until the end for fear of being raped on the way home. Violence inside and outside their homes is a daily reality, not just watched from a distance by sensationalist programs shown on television screens. Finally, daily work imputes to the educational process other issues that cannot be ignored, such as the physical demands that affect the subjects because of their working hours.

The following report cases describes situations experienced by the author of this work in the classroom as an YAE teacher at IF Baiano, which will make it possible to introduce the reality of YAE to the context explained above.

Let´s imagine the first scene. A student looked at the screen of the computer. He pretended to be doing the practical activity on the computer. Later, the teacher realized that he was not answering it. The teacher politely asked him what was going on. After a lot of insistence on my part, the student embarrassedly replied that he worked as a welder. At that day, his goggles got broken. His boss had not provided him with another pair of glasses and he could not afford to buy a new one. As a result, he had to work for the rest of the day looking directly and unprotected at the welding process. He feared of losing his job if he did not do so. For this reason, by working long hours in very bad

conditions, he was unable to see the content on the computer monitor in front of him.

On another occasion, I noticed that a student could not use the computer mouse. I offered to teach her. She was not very receptive for my assistance. Again, after some insistence on my part to find out what was going on, she explained that she knew how to use the mouse. She could not do it that day because she worked laundering for other people. During the workday, her fingers got hurt from working for almost twelve hours straight.

In the third situation, some of the students started to leave the room thirty minutes before the scheduled end time. I tried to understand what was going on. I asked why they were leaving, but they did not tell me why. Once again, I had to be very careful and insistent. They explained to me that a certain student, a neighbor of theirs, was going home and that they needed to go with him because they lived in a community where it was very dangerous for women to walk without a man around after 9 pm.

To conclude these brief reports, I would like to mention two situations related to student absences from classes. In the first case, I realized that a student had been absent from class for the second week running. So, I spoke to the other students to find out if anyone had closer contact with her. I was planning to find out if there were some students who could tell me what was going on. My intentions were to have some information. By this, maybe I could try to help in some way. At that time, during class, no one claimed to know what was going on. At the end of the class, I was called aside. The student explained to me that the absent student's husband was an alcoholic. The husband did not like her studying. He did not always allow her to go to school and often tore up her books and notes.

Finally, in the last situation, I was concerned about another student who was also absent from class. I asked the class again if anyone knew what was going on. Some of them informed that her son was involved in drug trafficking and had been murdered.

This is the reality that sparked the importance of investigating the process of emancipation in the YAE with these individuals. These young people and adults need to see themselves as subjects with possibilities. They can critically understand and change the reality of the world around them.

They need to have a voice and free themselves from social silence. It is crucial that they wake up to the importance of dialogue in a social environment. They need to freely express to their boss that the company needs to provide them with protective equipment. They need to communicate without fear that the equipment is crucial to work. They need to address the fact that, without the equipment, they are at the risk of having their vision permanently compromised. The educational process can improve their ability for a frank and fearless conversation with the teacher. By this, they can explain that they know how to use

the mouse, but that they will not be able to do the activity because they are laundering for others and their fingers are hurting. The educational process can make them aware that hard work is not a demerit. The work is not something to be ashamed of, but rather a virtue that dignifies one's being. The school should be a safe space that promotes equality. The students should talk to the school directors and request, for safety reasons, that transport can be provided for the YAE students on the night shift. The classroom should be a space where these students can express the need to ask the school for help, whether psychological or pedagogical, so that they do not have to face the drama of alcoholism, violence and drugs that affect their families alone.

The world is not made up of determinisms. The situation in which they are is not immutable.

The social conditions of the students lead to this research and problematization. Both are needed to overcome passivity in the world around them. They reinforce the overcoming of naïve curiosity by critical curiosity. The student can ask himself: "Is needing a job worth the cost of going blind"? Why can a teacher not understand an YAE student who, due to a physical limitation because of excessive work, cannot handle a mouse? If the school provides psychological help, why do I not allow myself to enjoy this right, which is already the fruit of other struggles? If the school provides evening transportation for undergraduates who live in another city, why does it not offer that to YAE students, given that in the city of Caty there is no public transportation when classes end? What is the reason for this exclusion?

This work sees educational robotics, when based on a socioconstructivist perspective, as a pedagogical possibility to enhance the process of emancipation of these subjects. The idealization of robots to carry out tasks thought up by the students themselves enables the exercise of collaborative, dialogical, investigative, reflective, problematizing, and transformative practices with respect for cultural identity and knowledge acquired throughout life. The values are seen as emancipatory principles investigated in this research.

Thus, this article presents the outline of a doctoral research project underway within the Postgraduate Program in Education and Contemporary Studies of the Universidade do Estado da Bahia (UNEB). We investigate how to enhance the process of human emancipation of YAE students using educational robotics in pedagogical interventions. We defend the thesis that this process of emancipation can be enhanced using educational robotics when based on a Socioconstructivist Pedagogical Design (SPD) intertwined with emancipatory principles.

The iterative cycles of the research are being carried out at the Catu Campus of the IF Baiano. The IF Baiano is an educational institution that unconditionally supports Youth and Adult Education and is actively endorsing and supporting the project. The director of the insti-

tution formally authorized the research through the document "Term of institutional authorization of the co-participant".

The research adopted the methodological principles of Design Based Research (DBR) and was structured in four phases. The first dealt with the analysis of the problem, the second with the development of the interventionist action, the third with the iterative cycles of application and improvement of the interventionist action and the fourth and final phase dealt with reflections and the search for design principles and implementation improvements.

This article, however, is restricted to discussions inherent to the second and third phases of the research. The second phase required the development of the SPD (the object of this article's central discussion) and the third phase made it possible to run an extension course conducted by the SPD, created and mediated by educational robotics for IF Baiano YAE students, with a 48-hour workload (each course configured an iterative cycle of application and improvement of the interventionist action).

Thus, the section presented here first addresses the motivations that led to the adoption of DBR as a research method. After this, this article discusses the methodology used to build the SPD and then presents the SPD developed through the design framework and design matrix built collaboratively with the participation of the main author of this article and the YAE students who took part in the research. Next, the partial findings revealed at the end of the first cycle are presented. We point out the emancipatory principles and indicator investigated that were successful from the application of the design created, as well as those that need attention and will consequently serve as a starting point for the redesign of the SPD prepared.

Finally, it is important to highlight the agenda of the educational institution where the iterative cycle discussed here took place. The practical intervention took place at IF Baiano, a federal institution, which in August 2018 celebrated the centenary of its foundation for educational activities.

The IF Baiano operates in the face-to-face and distance learning modalities. It offers basic education in the modalities of the technical courses integrated in high school or subsequent. The students can choose courses in agriculture, food, chemistry, surveying, oil operation and production, computer networks and, finally, the gastronomy course offered in the Youth and Adult Education Modality. In addition to secondary education, it also offers higher education courses in Food Technology, Systems Analysis and Development Technology and Chemistry, and postgraduate courses (lato and stricto sensu) in Specialization in Science Education and Popularization of Science and the Professional master's degree in professional and Technological Education.

Its activities have contributed to the development of the local area of identity. The courses provide new professional opportunities for the

citizens of these communities. They can (re)insert themselves into the world of work through educational training and professional qualification. The institute offers a possibility for qualification in face of the ever-increasing demands for adequate specialization to carry out work activities in a wide variety of areas. This professional qualification also has other benefits for the community, such as improved average earnings, lower unemployment rates and a higher human development index.

2.0   Why DBR?

The research was guided by the DBR. This methodology makes it possible to deal with complex problems in educational practice, filling a space that had not hitherto been adequately occupied by other methodological approaches in educational research and making it possible to approach...

... complex problems in real contexts, in collaboration with practitioners; integrating known problems with design principles and hypotheses with technological advances to make plausible solutions to these complex problems; and conducting rigorous and reflective research to test and refine innovative learning environments, as well as defining new design principles (Reeves, 2006, p. 58).

By enabling the construction of research that designs, develops and effectively applies pedagogical interventions in real-life contexts, DBR is affirmed as "... a way to strengthen the ties between academia and educational practice through collaboration in solving problems of mutual interest" (Nonato & Matta, 2018, p. 16). It harmoniously integrates theory and practice. It provides an appropriate methodological approach for working with complex educational problems that experimental research or qualitative research alone could not handle until then.

DBR advocates five macro characteristics which according to McKenney and Reeves (2012) are: theoretically oriented, interventionist, collaborative, fundamentally responsive and iterative. These characteristics are consistent with the research carried out. It denotes the assertiveness of the choice of DBR to conduct it, based on the following arguments:

The research is theoretically oriented. It is based on the understanding that the theories involved with socioconstructivist – postulated by Vygotsky (1978) – and with human emancipation – defended by Freire (2005) – are initially configured as a starting point. Both theories serve as foundations and as support for the elaboration of the pedagogical proposal.

It is interventionist when it develops and applies, based on a theoretical foundation intertwined with the specific context of the YAE, a pedagogical intervention using educational robotics with a view to

enhance the emancipatory process of the students of this type of education.

It is collaborative when it builds a partnership between the researcher and the research subjects. The connection is made between academia and the community, based on a relationship of non-vertical dialogue. Its perspective considers respect for human dignity and the awareness that this collaboration reinforces the pedagogical act as a collective act. The collaborative construction of the SPD demarcated the collaborative characteristic advocated by McKenney and Reeves (2012) in the development of this study.

Finally, it is characterized as fundamentally responsive when it proposes to investigate an element. This research question requires a practical intervention so that it can be answered. Finally, it is iterative when it defines iterative cycles for the application and improvement of the interventionist action.

3.0 The methodology adopted to build the SPD responsible for driving the cycles

Because of its iterative nature, the DBR assumes that in rare cases a single application of the interventionist action will produce the evidence needed to make it solid. This means that further cycles of refining and maturing the solution are needed, and it will become increasingly robust.

A key idea is that when the intervention prototype in each intervention does not unfold into the expected result for that iteration, it follows that the intervention is not yet good enough – in other words, the stated design principles (or intervention theory) for that iteration are not yet good enough or are not yet emerging. This results in a redesign or refinement of the intervention that goes hand in hand with the refinement of the intervention theory or design theory ... (Plomp, 2018, p. 47).

Understanding the importance of cycles for the DBR, the research under development considered the realization of iterative cycles of application and improvement of the interventionist action. Each cycle was carried out in the form of an extension course with a workload of 48 hours for the YAE student public.

These cycles were led by a SPD based on Matta's (2012) methodological proposal which states that it seeks to "... prepare the reader so that he/she can carry out socioconstructivist design and use it to design digital content and other pedagogical processes" (p. 245).

The contributions of Vygotsky (1978, 2012) and Freire (2001, 2005) were of fundamental importance to the construction of the proposed design. Vygotsky's (1978, 2012) writings made it possible to mediate the discussions responsible for constructing the framework and the design matrix based on the understanding that knowledge is not found

in the subjects, but that its construction takes place from the inter-action between them and the object, and that this construction is built in a way that is intertwined with socially produced culture. In this way, interaction, collaboration and collective construction based on a given social context were socioconstructivist principles advocated by Vygotsky, which were fundamental to the construction of design.

The theoretical background in Freire (2001, 2005) made possible to understand that this author does not propose a system or a method to emancipate workers or the oppressed, but rather seeks, from their perspectives, to work on understanding the importance of playing a leading role in their life stories. The process can lead them to recover their stolen humanity and exercise dialogicity. The Freirian methodology can help the students to articulate knowledge and social relations. The subjects involved in the teaching-learning process can value their life stories and respect their culture. It can also reflect on the need to confront the difficulties that permeate their world. Thus, some of the assumptions contained in Freire (2001, 2005) are assumed here as emancipatory principles that were analyzed, as will be presented in Section 6.

Thus, the first two stages recommended by Matta (2012) were adopted for the construction of the SPD. For the first stage, which deals with macro design issues, the framework proposed by this author was used. To carry out the second stage, which deals with the micro issues of design, we used the matrix in Filatro (2008).

Summarizing what has been discussed above, Figure 1 below shows a conceptual map of the methodology adopted.
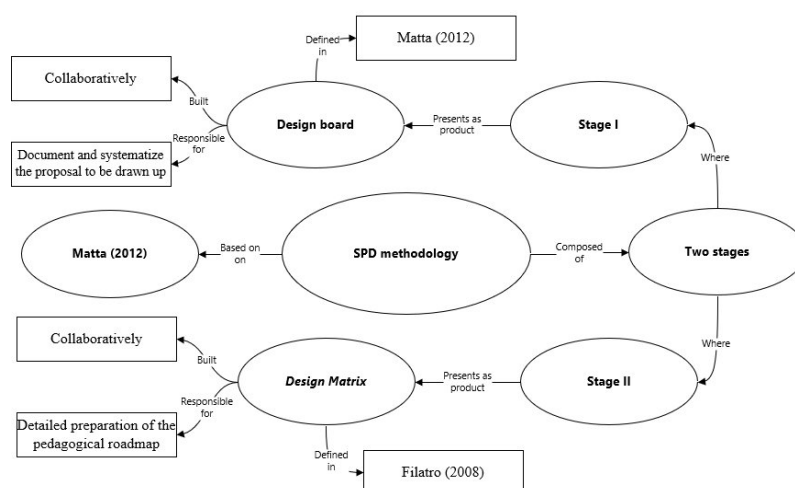
Figure 1. Conceptual map of the methodology defined for building the adopted SPD.

Based on the model proposed by Matta (2012), construction of the design began with the participation of the main author of this article

and the YAE students who took part in the research. YAE teachers did not participate in this construction, only the main author of this article and YAE students were actively involved in the design process and the subsequent realization of the cycles.

Assuming that the design was built with the subjects, not for the subjects, and paying attention to what Damodaran (1996) advocates, their involvement in the process took place in a participatory manner where they took part in decisions that influenced the whole process.

Three four-hour dialogical meetings were held. At the first meeting, held on April 18, 2023, the project was discussed with the participants by introducing a topic to be discussed, followed by one or more provocative questions related to the issue of interest to broaden the dialogue. These dialogues resulted in the collaborative construction of the design framework.

In the second dialogical meeting, held on April 25, 2023, the micro issues of design were discussed, using the same logic defined for the first meeting, when the design matrix was constructed.

Finally, in the third meeting, held on April 27, 2023, the design was validated, when the framework and matrix drawn up from the discussions held in the first two meetings were discussed and validated once again.

The meetings were conducted based on the socioconstructivist assumptions of interaction, contextuality, mediation and collaboration. Considering that Vygotsky's (1978) learning processes take place in the interaction between peers in each sociocultural context, the construction considered: the interaction between the students; the interaction between them and the mediator; the interaction between them, the robotics kit and the social context in which they are inserted.

Contextuality, on the other hand, helped structure the design by referring to the need to propose projects that are intertwined with the historical and social context of the subjects, paying attention to the preponderant relationships that arise in the environment, cultural issues and their desires. Mediation, on the other hand, was important to this construction as it maintained an intertwined relationship with interaction, paying attention to the importance of "... well designing the environments and strategies of the instances in which the encounter between the internal and the external will take place, between the singularity of a subject and the collaborative nature of the social context" (Matta, 2012, p. 249).

It can be said that, to a certain extent, the construction process lived up to expectations. The meetings provided a collective social process, with ample respect for contradiction as a primordial characteristic of essentially human processes, and the fruitful dialogues corresponded to the idealized plans for collaborative construction. Admittedly, the

participation of the YAE students was not equal, with some partici-
pating more than others, but this was somewhat expected.

4.0   Introducing the built SPD

From the set of dialogues woven during the meetings, the design
framework shown in Table 1 below and the design matrix shown in
sequence in Table 2 emerged.

Table 1

Design framework built for this study

Educational solutions	Technical solutions
Theme / Pedagogical procedure to be designed: Pedagogical proposal materialized in the form of an extension course, using educational robotics based on a SPD imbricated in emancipatory principles that makes it possible to investigate the process of emancipation of YAE students. **Objectification:** To enhance the process of human emancipation of YAE students using educational robotics based on an SPD imbricated in emancipatory principles.	**Media / Practical technological solution:** As media, videos and animations related to the content covered will be used and as a practical technological solution, educational robotics kits will be used during discussions on the content and during practical activities.
How will the content be covered? Aiming for social **interaction** between the students, their environment, and the content to be discussed, the mediator will be responsible for encouraging discussions, bringing a problem situation to be solved (motivating question) related to the subject(s) being discussed. The problem situation should intrinsically associate the content to be covered with the reality of the participants, to trigger discussions on the topics on the agenda. The students will then carry out additional research on the World Wide Web or in the campus library and bring their findings and doubts to the debate. This is not an explanatory lesson along the lines of passive methodologies; the findings are shared by everyone, and the doubts discussed, when they persist, will generate new cycles of research and debate until they are resolved. **What strategy will ensure contextualization?** Each practical activity to be carried out will be	**Format:** Extension course with a 48-hour workload, divided into 16 3-hour meetings to be held twice a week in the afternoon, offering ten places to YAE students from IF Baiano.

based on a problem situation that will necessarily emerge from circumstances related to the **context of** the participants.	
What strategy will guarantee interdisciplinarity? In view of the inherent interdisciplinary nature of educational robotics, interdisciplinarity will be ensured during the activities developed by encouraging the construction and/or assembly of the mechanical components to be used in the robotic devices; by making it possible to understand and use logical mathematical concepts in programming the controllers; by making it possible to apply the principles of electronics needed to build the robots; and, finally, by encouraging the investigation of the physical and chemical quantities involved in the operation of the sensors and actuators used.	**Technical requirements:** Kits will be used that adopt a more autonomous perspective, allowing them to be built in different formats, as well as being used for coding. The starter kits for Arduino marketed by Robocore will be used, but in their absence, controllers compatible with the Arduino UNO, electronic and mechanical components, sensors and actuators of any model can be used, if they are compatible with the controller adopted. The robots will be programmed using block coding using ArduBlock.
What mediation strategies should be used? Seeking to work on the encounter between the knowledge that the students bring with them (the singularity, the internal) and the collaborativity of the social context (the social interaction, the external), both the practical activities and the final project will be **mediated** by educational robotics in observation of the exercise of the following **emancipatory principles**: collaborative practice, dialogical practice, investigative practice, reflective practice, problematizing practice and transformative practice. The construction of the activities will take place in teams to be defined by the students themselves, enabling not only intra-team **collaboration** but also inter-team **collaboration.**	
What are the strategies to guarantee the subjects' engagement? Robot constructions intrinsically related to the area of gastronomy that arise from the collective challenge of designing something that has a tangible purpose for a real need.	**What is the technical presentation vehicle?** Robots, in all their different formats, built by YAE students.

Evaluation Proposal:

Formative and summative evaluations will be used, which will perform a dual function: Firstly, they will provide support for research into the emancipation process and, secondly, they will provide elements that make it possible to rethink/adjust the elementary/formative units or iterative cycles.

To evaluate and adjust the cycle while it is still in progress, formative evaluations will be used for each elementary/training unit that takes place within the same cycle, using

participant observation throughout the unit and the focus group held at the last meeting of each unit. This evaluation is concerned with the ongoing process, enabling corrections and adjustments that will be reflected in the next formative unit within the same cycle and not just in a subsequent cycle.

The summative evaluation, on the other hand, will aim to evaluate the entire cycle in a macro way, using the focus group held at the last meeting of the iterative cycle, where its results and consequent changes will be reflected in subsequent cycles.

Useful information for building the Pedagogical Guide:

The design matrix, to be built from this design framework, will be the pedagogical guide for the iterative cycles of application and improvement of the interventionist action. In this sense, it is important to note that at the start of the course, the students themselves must define the final project (a single project for all the teams) which will be developed during the course as knowledge is built up.

Note. Adapted from Matta (2012).

The discussions that arose from the design framework shown in Table 1 above resulted in the construction of the design matrix shown in Table 2 below.

Table 2
Design matrix built for this study

Elementary unit	Objectives	Roles	Activities	Duration and Study	Tools	Contents	Evaluation
1	Introduction to robotics	• Understand the concepts surrounding the world of robotics. • Discuss the role of robotics in the world of work. • Define the final project to be built. • Discuss the use of robotics in gastronomy. • Work on the emancipatory principles adopted in the activities and discussions	Mediator: • Mediate the meetings, conflicts and raise provocative questions to lead the dialogues. • Pointing out ways to, and accompanying, the resolution of any difficulties that may arise along the way. • To analyze the attitudes, behaviors and actions of the students, in strict observation of the emancipatory principles defined as important to the process of emancipation. • Conduct the focus group. Students: • Actively participate in the discussions and activities proposed. • Define the final project. • Define the teams that will work during the cycle.	• Discussions based on the analysis of introductory videos on robots and robotics. • Discussion of opportunities envisioned by the participants where robotics can help with the difficulties they face in their day-to-day gastronomy course. • Get to know, investigate and take ownership of the robotics kit to be used during the cycle.	- Two 3-hour meetings.	• Educational robotics kit made up of controllers, sensors, actuators, electronic and mechanical components. • Documentaries covering the initial concepts of robotics. • Videos presenting the use of robotics in gastronomy.	• Initial concepts of robotics, definitions of robot and robotics. • Robotics in the current scenario. • The relationship between robotics and the world of work. • Robotics in gastronomy. A villain? • Possibilities of robotics in the gastronomy course.	- Formative evaluation, using participant observation throughout the elementary/training unit and the focus group held at the last meeting of the unit.

Note. Adapted from Filatro (2008).

Table 2
Design matrix built for this study

Elementary Unit	Objectives	Roles	Activities	Duration and Period	Tools	Contents	Evaluation
Controllers 2	• Understand the function of the controller for the robotics environment. • Understand how a controller can be used in the world of gastronomy. • Get to know the Arduino and its component parts. • Learn to program the Arduino and start programming the final project. Work on the emancipatory principles adopted.	See roles defined in the first training unit.	• Discussions based on the analysis of the introductory videos on controllers. • Practical resolutions of group exercises involving programming in text mode and in - Arduino blocks	- Four 3-hour meetings.	• Educational robotics kit made up of controllers, sensors, actuators, electronic and mechanical components. • Software for programming in plain text (Arduino IDE). • Block programming software (ArduBlock and Tinkercad). Videos showing how different controllers work in the world of work and in the gastronomic field.	• Initial concepts about controllers, their functions and types. • Controllers used in the world of gastronomy, examples of application and areas in which they are used. • Introductory information about Arduino, the reasons for its current widespread use, its component parts, how to connect and handle the controller. Programming the Arduino in plain text and in blocks.	See definitions in the first training unit.

Note. Adapted from Filatro (2008).

Table 2
Design matrix built for this study

Elementary unit	Objectives	Roles	Activities	Duration and Period	Tools	Contents	Evaluation
Sensors 3	• Understand the function of sensors in the robotics environment. • Understand how sensors can be used in many different areas of human activity and in the world of gastronomy. • Learn how to configure and program sensors for use in the most diverse tasks in the world of gastronomy and program the sensor(s) for the final project. Work on the emancipatory principles adopted.	See roles defined in the first training unit.	• Discussions based on the analysis of the introductory videos on sensors. • Practical group exercises involving the configuration and programming of different sensors in the controller. Configuration and programming of the final project sensor(s).	- Four 3-hour meetings.	• Educational robotics kit made up of controllers, sensors, actuators, electronic and mechanical components. • Specific sensors defined by the research subjects to be used in gastronomy-related activities. • Software for programming in plain text (Arduino IDE). • Block programming software (ArduBlock and Tinkercad). Videos showing how different sensors work in the world of work and in the gastronomic field.	• Definition, initial concepts and examples of sensors. • Examples of the use of sensors in the most diverse areas of human activity and in the world of gastronomy. Programming sensors for use in the world of gastronomy.	See definitions in the first training unit.

Note. Adapted from Filatro (2008).

Table 2

Design matrix built for this study

Elementary Unit	Objectives	Roles	Activities	Duration and Period	Tools	Contents	Evaluation
4 Actuators	• Understand the function of actuators in the robotics environment. • Understand how actuators can be used in many different areas of human activity and in the world of gastronomy. • Learn to configure and program different actuators for use in the most diverse tasks in the world of gastronomy and program the actuator(s) for the final project. Work on the emancipatory principles adopted.	See roles defined in the first training unit.	• Discussions based on the analysis of the introductory videos on actuators. • Practical group exercises involving the configuration and programming of different actuators in the controller. - Configuration and programming of the actuator(s) for the final project	- Four 3-hour meetings.	• Educational robotics kit made up of controllers, sensors, actuators, electronic and mechanical components. • Specific actors defined by the research subjects to be used in the activities involved in the gastronomy area. • Software for programming in plain text (Arduino IDE). • Block programming software (ArduBlock and Tinkercad). • Videos showing how different actuators work in the world of work and in the culinary field	• Definition, initial concepts and examples of actuators. • Examples of the use of actuators in the most diverse areas of human activity and in the world of gastronomy. • Programming actuators for use in the world of gastronomy	See definitions in the first training unit.

Note. Adapted from Filatro (2008).

Table 2
Design matrix built for this study

Elementary Unit	Objectives	Roles	Activities	Duration and Period	Tools	Contents	Evaluation
5 — Final adjustments to the project under construction and closing the cycle	• Rethink and, where necessary, redesign the mechanical components and visual presentation of the prototype built. • Rethink and, where necessary, adjust and/or refine the controller's programming; • Rethink and, where necessary, adjust and/or refine the operation of the sensors; • Rethink and, where necessary, adjust and/or refine the operation of the actuators; • Present the final project. Work on the emancipatory principles adopted.	See roles defined in the first training unit.	- Configuration, programming and adjustments of the actuator(s), sensor(s) and electronic components of the final project.	- Two 3-hour meetings.	• Educational robotics kit made up of controllers, sensors, actuators, electronic and mechanical components. • Acrylic sheets, medium-density fiberboard and aluminum sheets. • Software for programming in plain text (Arduino IDE). Block programming software (ArduBlock and Tinkercad).	• Content seen in previous units that needs to be discussed again to adjust the final project. Content not covered in the course that may add new knowledge to any refinement of the final project.	**Summative** evaluation, using participant observation and the focus group held at the last meeting of the cycle.

Note. Adapted from Filatro (2008).

5.0   The realization of the first cycle from the built design

Guided by the SPD composed of the matrix and the design framework presented, the first iterative cycle was then carried out during the months of May, June and July 2023. It was an extension course with a workload of 48 hours, divided into 16 meetings of 3 hours held twice a week in the afternoon. The course was attended by five students from the Integrated Technical Course to High School in Gastronomy in the YAE modality of IF Baiano.

Following the paths indicated by the design matrix, the first training unit presented the research subjects with the great challenge of defining the final project. This project had to be thought out collaboratively to idealize a robot that made sense to the subjects, based on the context and respect for their desires, the knowledge they brought with them and their cultural identity.

The subjects decided that they would build a robot capable of monitoring a kitchen, with the aim of preventing accidents caused by fires and/or gas leaks. The device would have to be capable of sensing the environment and in the event of smoke or gas being detected, it would need to warn those present in some way. Once defined, this robot would then be built throughout the course as the knowledge was produced.

During the second and third formative units, as discussions and activities took place that made it possible to understand sensors, the subjects had to define which sensor or sensors they would use in the project. On this occasion, research and debate led to the choice of the Mq-2 sensor module, which can detect smoke and gases such as butane, propane and liquefied petroleum gas.

During the fourth training unit, they had to define the actuators that would make it possible to warn those present in the kitchen of the possibility of a gas leak or the presence of smoke. At the time, the subjects decided that the warnings would be given in three ways: audibly, visually by means of a message on a display and visually by means of lamps or LEDs of different colors.

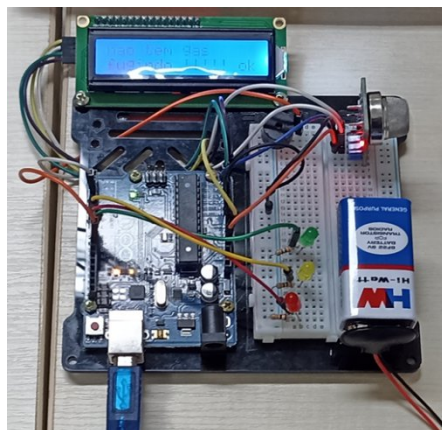Figure 2 below is an example of one of the projects built.

Figure 2. The built project

Carrying out this first cycle made it possible to observe some deviations from the original plan which led to adjustments in the design to be applied in the second cycle. The first observation showed that less time can be allocated to the first training unit, while the third and fourth require more time for the discussions needed to carry them out. The second observation led to the inference that there needs to be an adjustment between the number of theoretical discussions and practical activities in the first training unit, as it has a large theoretical load, which does not allow for more space to carry out the practical activities and the rich discussions that take place during them.

6.0   The partial results revealed at the end of the first cycle

During the cycle, participant observation and the focus group were adopted as data production devices, shown in Figure 3 below with their respective means of recording.
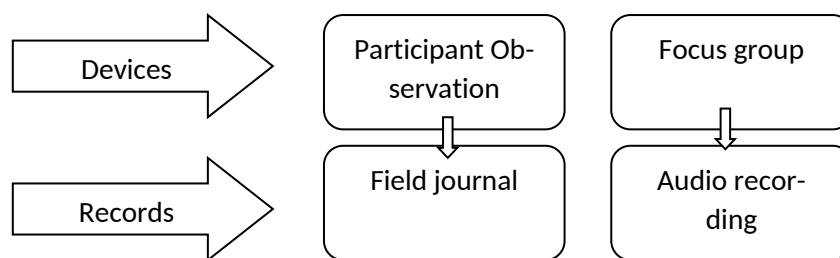

Figure 3: Data production devices and recording media.

Based on the data produced, the analysis was based on a structure made up of categories, emancipatory principles and indicators, where the emancipatory principles designated the phenomena to be investigated based on the observation of the indicators, as shown in Table 3 below.

Table 3

Categories, emancipatory principles and indicators

Categories of analysis	Emancipatory principles	Indicators
Dialogic action	Collaborative practice	Sharing experiences with peers
		Building solutions together
	Dialogical practice	Constant dialogue with others
		Dialogue with the mediator
	Investigative practice	Search for information

Critical thinking		Analysis of findings
	Reflective practice	Identification of main ideas
		Searching for solutions
		Comparison with other developed solutions
		Revision of concepts and/or recognition of errors
	Problematizing practice	Insertion in the problem under study (respect for cultural identity)
		Knowledge acquired throughout life
Self-perception	Transformative practice	New approaches to problems
		Taking up the challenge
		Change of attitude

Note. Own authorship.

To give you an idea of the events on which I focused in relation to the emancipatory principles and indicators shown in Table 3 above, by way of example, the analysis of the collaborative practice will be explained below, which happened because of observing the sharing of experiences with peers and the joint construction of solutions.

The exercise of sharing experiences with peers was observed from the perspective that by sharing with others the experiences they have had from solving the practical activities of building robots, subjects have the possibility of expressing themselves, explaining what they have done, getting to know what others have built, listening to others' opinions, reflecting on what they have built based on what others have presented to them and helping each other.

This sharing in the first elementary unit proved to be timid, due to the observation of two factors: The subjects were still getting to know each other, because although they attended the same gastronomy course, they were not all from the same class, and due to the great theoretical weight of the first unit, which did not favor the exchange of experiences as a result of carrying out the practical activities as happened in the subsequent units.

Despite these two issues, even in the first unit the exchange of experiences was evident when the last task of the unit was carried out, responsible for defining the project that would be built throughout the course.

When carrying out this task, the subjects had to exchange ideas based on their experiences in the world of gastronomy to reach a consensus on which project would be developed by the teams. This activity was the main agent behind the process of bringing human relations closer together, breaking down the initial barrier of the natural distance that had existed between the subjects up until that point.

During the other elementary units, sharing experiences became a recurring practice, fostered by the dialogue that took place at the end

of each lesson not only between the members of the respective teams, but also between the teams. In these moments of sharing, illustrated in Figure 4 below, the teams discussed what they had managed to build, the difficulties they had encountered, the obstacles they had yet to overcome and the help they offered each other.

Figure 4. Sharing experiences between teams

On these occasions, as defined in the design matrix, the sharing of experiences at the end of each class was motivated by the following questions: What difficulties were encountered in carrying out the activities? Were they resolved? How did the activities developed by the teams differ?

During the formative evaluation carried out at the end of the second elementary unit, the dialogues showed that the adoption of this practice enabled the subjects to exchange knowledge through social relationships, a fundamental characteristic of an emancipatory process, in agreement with Freire (2005) when he argues that "no one frees anyone, no one frees themselves alone: men free themselves in communion" (p. 71). The following dialogue was recorded during the focus group:

> Researcher: What did you think of the possibility of sharing experiences at the end of each lesson?
> Participant B: I thought it was good, teacher, because you can learn from what your colleague has done and explained.
> Participant D: I liked it. When her colleague says how difficult it was, we can see that it wasn't just us. We see that everyone didn't understand something.
> Participant C: I liked it too. Mainly because the teams can say how they did the activity and we understand that what they did was the same as ours, but in a different way.

The indicator *joint construction of solutions*, in turn, sought to investigate whether, through the construction of robots, the research sub-

jects would be able to work as a team, carrying out tasks with "several hands" in a process of social interaction in pursuit of a common goal.

In addition to the fact that joint work was previously established in the framework and design matrix, by defining that the activities and the final project should be carried out as a team, participant observation made it possible to understand that this joint

construction was motivated during the activities by the need for mutual help between the research subjects as a result of the complexity that the construction of the robots imputed to the process. Programming logic and electronics required other skills with which the subjects were not yet familiar.

The dialogue recorded in the field diary during the third elementary unit, on May 25, 2023, when they were carrying out one of the configurations necessary for the operation of the gas sensor that would be used in the final project, exemplifies the research subjects' feelings about the importance of building solutions together. At the time, the other members of one of the teams did not show up for the meeting and the only participant present had to face the difficulties of doing all the work alone. At the end of the meeting, I provoked the following dialogue:

> Researcher: Participant D, how did you feel about working alone today?
> Participant D: Bad.
> Researcher: And why did you think it was so bad?
> Participant D: Because in a team people help each other. I had a hard time on my own and there was no one to help me.
> Researcher: But you managed to do the task on your own. Isn't that also a victory? Participant D: Yes, it's a victory, I didn't think I was going to make it.
> Researcher: Yes. Didn't I tell you at the beginning of the lesson that even without your classmates you could do it?
> Participant D: True, professor, but I'd still prefer it if my colleagues were here with me.

Although Participant D, to her credit, managed to complete the task alone, marking that space as "a time of possibilities and not of determinism" (Freire, 2001, p. 59), in her view the absence of her teammates to help her work, share her anxieties, answer questions and think together had a greater impact than the courage she had to face the activity alone. This was an important moment, as it highlighted the importance of the subjects exercising their presence in the world in communion and interaction, signaling that for that collective the exercise of jointly constructing solutions made sense.

The questions presented here about the sharing of experiences and the joint construction of solutions made it possible to highlight the exercise of collaborative practice during the cycle, which is important to the research carried out based on the understanding that in the relationship with the other, the subject becomes historicized and actively and critically constructs their ontological vocation of being a subject.

The analysis of the other emancipatory principles and indicators followed the same logic of observing the phenomenon under investiga-

tion and, once this had been completed, the data was grouped together in a table to provide an auxiliary tool to help observe the phenomenon from a different, more pragmatic perspective.

Without losing sight of the fact that education cannot be understood as a technical process and that "evaluation cannot be aimed solely at comparing, in an aseptic manner, results achieved through pre-established, observable, quantifiable objectives" (Saul, 2006, p. 45), the aim here was not to statistically treat the data, nor to control the emancipatory principles or indicators, but rather to monitor based on the quantities and (re)think the quality of the process.

Thus, as indicated in the design matrix, four formative evaluations were carried out (F1, F2, F3 3 F4), one at the end of each elementary unit, and a summative unit (S1) at the end of the cycle, in each of which we sought to identify situations in which both the research subjects through the focus group, and the researcher through participant observation, understood that the indicators were able to be exercised in the field as a result of the elaborated design, resulting in the data shown in Table 4 below.

Table 4
Verification of the exercise of indicators in the field

Emancipatory principles	Indicators	Findings in the evaluations					Total
		F1	F2	F3	F4	S1	
Collaborative practice	Sharing experiences with peers	4	5	6	6	6	27
	Building solutions together	4	6	6	6	6	28
	Total for the collaborative practice:	8	11	12	12	12	55
Dialogical practice	Constant dialogue with others	4	6	6	6	6	28
	Dialogue with the mediator	5	5	6	6	6	28
	Total of the dialogic practice:	9	11	12	12	12	56
Investigative practice	Search for information	5	6	6	6	6	29
	Analysis of findings	3	5	6	6	6	26
	Total of the investigative practice:	8	11	12	12	12	55
Reflective practice	Identification of main ideas	6	6	6	6	6	30
	Searching for solutions	5	6	6	6	6	29
	Comparison with other developed solutions	0	6	6	6	6	24
	Reviewing concepts and/or recognizing errors	0	0	0	2	2	4
	Total reflective practice:	11	18	18	20	20	87

Problematiz-ing practice	Insertion in the problem under study	5	6	6	6	6	29
	Knowledge acquired throughout life	5	6	6	6	6	29
	Total of the problematizing practice:	**10**	**12**	**12**	**12**	**12**	**58**
Transforma-tive practice	New approaches to problems	0	3	3	6	6	18
	Setting yourself the challenge	5	6	6	6	6	29
	Change of attitude	0	4	6	6	6	22
	Total of the transformative practice:	**5**	**13**	**15**	**18**	**18**	**69**

Note. Own authorship.

Table 4 summarizes the number of findings from the exercise of each indicator during the cycle, in the view of the YAE students and the researcher. For example: Number 4 (in sharing experiences with peers / F1) indicates that 4 participants said they understood (through participant observation or the focus group held during the first formative assessment – F1) that sharing experiences with peers was practiced during the first formative unit.

Considering that for each indicator in Table 4 a total of six findings were possible in each evaluation (F1, F2, F3, F4 and S1), since there were six participants in the research (five YAE students and one researcher), the emancipatory principles *collaborative practice*, *dialogic practice*, *investigative practice* and *problematizing practice* could have a maximum of sixty findings each. The reflective practice could have a maximum of one hundred and twenty findings, and transformative practice ninety.

Thus, it can be seen that of the six emancipatory principles investigated, four showed percentages between 92% and 97%, demonstrating that the SPD followed an assertive path in the first cycle, making it possible, in the view of the YAE students and the researcher, to exercise collaborative practice, dialogic practice, investigative practice and problematizing practice.

As for the reflective practice and transformative practice, these obtained percentages of 73% and 77% respectively, indicating gaps that could be improved for the next cycle. The indicator *review of concepts and/or recognition of errors* and the indicator *new attitudes to problems* were the most responsible for the low percentage shown in the respective emancipatory principles to which they are related.

It should also be noted, from the analysis in Table 4, that the two indicators mentioned above had a low finding rate in the first three formative assessments, which took place halfway through the cycle. This shows that the issues investigated in these two indicators require more time or another type of approach, which will subject the SPD built to a new analysis (redesign) in the search for solutions that allow it to evolve because of these two gaps observed.

7.0 Conclusion

Understanding that working on emancipation in the YAE should be a constant object of effort on the part of education, this article presents the design for conducting an interventionist action that sought to investigate the process of human emancipation of the students of this type of education using educational robotics based on a SPD imbricated in emancipatory principles.

The methodology adopted for the construction of the SPD allowed for collaborative work with the research subjects, considering their wishes and highlighting the need to create robotic prototypes that are intertwined with their historical and social context.

The possibility of redesigning the developed SPD showed the positive impact that the iterative characteristic of the DBR had on practice in the study carried out, since it made it possible, as a result of the data revealed at the end of the first cycle, to analyze a solution developed for applied research in the educational field and rethink it, with a view to refining the design built and putting it to the test again in a subsequent iterative cycle.

The results obtained did not point to whether the research subjects were emancipated, because if we understood emancipation as a life-long process, this study would not be able to answer that question. They revealed the potentialization of the emancipation process of the subjects participating in the research, based on the fact that the emancipatory principles worked on during the iterative cycle allowed them to exercise collaborative, dialogical, investigative, reflective, problematizing and transformative practices, achieving the dialectic that "... small changes in any process accumulate until a moment when a radical transformation of state occurs in the process" (Amstel, 2007, p. 7).

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