



Sustainability-focused international PBL project

Rethinking digital education for individuals of low socioeconomic status

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Sustainability-focused international PBL project: Rethinking digital education for individuals of low socioeconomic status

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Abstract

Providing access to education for individuals of lower socio-economic status is a significant way to reduce poverty, as it empowers them to grow as professionals and as individuals. Although there is an increasing sense of urgency to promote these changes, notably motivated by the Sustainable Development Goals (SDGs) set by the UN 2030 Agenda, there are still few successful ways to solve this problem on a large-scale. As digital technology develops and affordability increases, new ways to share quality educational content are created. In an exploratory case study, with a qualitative approach, this paper presents the development of a digital application focused on providing quality educational content directed to vulnerable groups that lack access to formal learning experiences, specifically focused on waste pickers in Brasilia, Brazil. The main data collection methods used to make the decisions through the development process were observation, surveys, and interviews. Within the framework of Problem Based Learning (PBL) an international cross-disciplinary collaboration among different universities, the project, denominated "Mobile Education", involved: (i) the design and implementation of a system consisting of both a web and mobile application; (ii) the research of a viable business model to provide long-term sustainability for the project; (iii) and the creation of a pilot course of financial education for the preliminary target group, i.e., waste pickers from Brasilia, Brazil. Conclusively, the project aims to positively impact social transformation for individuals who work at the Waste Sorting facilities and lack financial knowledge. The Mobile Education project resulted in a functional version of the app (Web and Mobile) as well as the delimitation of a viable business model to keep it providing digital equality in Brazilian education.

Keywords: Digital Education; Problem Based Learning (PBL); Active Learning; Lower socio-economic backgrounds; Computer Engineering; Production Engineering.

1 Introduction

In 2018, the second largest dump in the world, the largest in Latin America, located in Brasilia, Brazil, ended its activities (ISWA, 2019). Consequently, the approximately 2500 waste pickers who depended on recycling waste from the dumpsite, found themselves without a source of income. With the goal of solving this problem, the government created sorting facilities so that waste pickers could still earn income by continuing to contribute to the local recycling chain (Barbosa, 2018; Campos et al., 2018, p. 239). Having provided them a better and prepared place to waste collection, this change represented a relevant transition of working conditions (Campos et al., 2018, p. 226). However, this move of the waste pickers to sorting facilities, came with the side effect of income reduction for the waste pickers. This happened due to the amount of waste available in the sorting facilities being smaller than in the dumpsite (Campos et al., 2018, p. 238; Britze, 2019). In this process, government entities, researchers and waste picker leaderships diagnosed that, in addition to their low incomes, the lack of financial education of this population was a bottleneck for the waste pickers to get their basic needs (Cruvinel et al., 2019).

Aware of this challenging scenario, an international, cross-disciplinary collaboration between Aalborg University (AAU) and University of Brasilia (UnB), the Mobile Education Project (MEP) of the EPIC SDG Challenge (SDGC) initiative, started in 2019 with the goal of providing the support to the waste pickers on their educational gaps through digital learning. Since the conception of the SDGC initiative, students have been

working within a Problem Based Learning (PBL) approach, with different teams from both universities working on solving the problem, as a result many premises were validated.

This article presents the development of the most recent MEPs, in which a digital solution is designed and implemented in the context of educating individuals of low socioeconomic status, especially contributing to the Sustainable Development Goals #4, #8, #10 and #17 from the 2030 Agenda (Assembly, 2015). The long-term goal is to increase social mobility, enabling the waste pickers, and in future, other lower socio-economic groups, to seek better and higher paying jobs, in addition to the increases in their competences. Usability, maintainability, and financial viability of the product are prioritized, increasing the long-term sustainability of the solution.

The structure of the article reflects the Problem Based Learning (PBL) framework applied throughout the project, and thus consists of the following chapters: (i) Introduction; (ii) Problem examination and analysis; (iii) Methodology; (iv) Product Development and Implementation; and (v) Conclusion.

2 Problem examination and analysis

The project focus is defined by analysing the specific use case in detail based on the initial premises from the problem. In this section, the problem analysis is comprised of three main subsections: Problem Identification; Problem Examination; and Existing Solutions. Therefore, the problem identification, examination and analysis contain the literature review within a problem based learning approach, in addition to both the results of field research of the problem, and research about existing solutions.

2.1 Problem Identification

The Mobile Education Project focuses on a societal problem: the gaps in the education of waste pickers. The absence of educational access is an issue for vulnerable groups in Brazil, who usually need to enter the workforce early, hampering their learning experiences (Sonia M. Dias, 2011). Specifically, in the case of waste pickers in the Centre-West of Brazil, where Brasilia is located, this scenario is evident by the average rate of illiteracy among adult waste pickers at 17.4% (IPEA, 2016, p. 27). Additionally, 89.2% of the waste pickers have not completed basic education (IPEA, 2016, p. 27) and, therefore, have an extra challenge finding a better job (IPEA, 2016, p. 178). Even though the income they earn from the waste collection is low (Ferraz, C., 2021), especially after the closure of the dumpsite, the way they manage their income can also influence in their financial health. According to the coordinator of one of the waste sorting centres, Cleusimar, interviewed by our team, "it is not uncommon for several waste pickers to run out of money well before the end of the month, even if some waste pickers in a similar situation do not go through the same problem", indicating that, even though their income is low beforehand, the way it is managed has significant impact in their finances.

Therefore, the acquisition of financial education became evident as a central need for the waste pickers. Before providing education that empowers them to change their lives for the future, it is essential that they receive the education necessary to stabilize their current financial situations with better management of their present available resources. Consequently, creating a framework for digital learning content focusing on administration of personal finances is defined as the focus of the Mobile Education project.

2.2 Problem Examination

The determination to solve this complex societal and educational problem through a digital learning method raises two main different challenges: (i) designing and implementing the digital platform, in technical and usability aspects; (ii) deciding the educational and learning approach to be implemented. The challenges related to the technical development of the platform are specifically addressed in the topic 2.3, which deals with existing solutions. Thus, in this problem examination, the focus is the usability aspects of (i) and all aspects of (ii).

In this context, 25 waste pickers and 5 cooperative leaders were interviewed by the research team as part of the investigation process. Throughout the interview process, the goal is to acquire information about their educational backgrounds, their level of technological access, their acquaintance with digital education, their

preferred learning methods and approaches, and their greatest difficulties in managing their finances. The information about the waste pickers' educational level revealed that, generally, most of the waste pickers, 65.3%, have not completed elementary school (IPEA, 2016, p. 27) and have difficulties reading, writing, and interpreting.

Subsequently, the importance of adapting the course structure to provide a suitable learning experience is apparent. The interviews indicated that their level of technological access would be appropriate, since most of them, 88%, have phones and internet access. Accordingly, 80% of the group surveyed formed by the waste pickers and their leaders considered a learning mobile application a proper alternative to improve their educational access, since, in their perspective, mobile courses would fit their routines better than courses with scheduled time or in-person.

The decisions of attractive teaching methods and approaches have been pointed by the leaders of the cooperatives as potential points of contention, due to waste pickers' resistance to education in general, occasioned by their past experiences with in-person courses, which were, as described by Campos (2018, p. 235 & p. 237), part of the transition period of the dumpsite closure. Whilst considering this possible issue, the leaders reinforced the importance of using simple communication and contents to keep the waste pickers interest. After the interviews, the requirement for the course is defined with focus on developing the waste pickers' financial management skills through a mobile application with basic financial contents in a simple and didactic way.

2.3 Existing Solutions

Before designing and implementing a solution, research is done into similar products to incorporate the findings into the design and implementation process, ensuring that this project's outcome is singular and novel whilst also gaining insights into potential development paths. Broadening the category of this project into digital learning, a list of most successful applications is analysed, and the main characteristics highlighted (Table 1).

Table 1. Main references of existing solutions.

Name	Kahn Academy	Rise Articulate	Udemy	Kolibri
Description	A course provider focused on mathematics, with recent expansions into science, arts economics etc.	A user-friendly course creation / course completion tool.	A simple course-based learning environment supporting text, images, audio, and video.	A platform used to share already downloaded courses from other platforms between phones whilst offline.
Features	Heavily focused on video for learning. Quizzes to show progress. Gamification of learning. Downloading of videos on their app.	User focused approach, with a great User experience (UX). High quality course creation tools, making it simpler to create engaging courses.	Course creator with a big backlog of other courses. Downloadable content. Support for assignments beyond just quizzes.	High quality offline sharing tool. Open source – can be implemented and modified.
Issues for use case	Downloading videos manually. Unable to create new courses in Kahn, as it is only done by them and their partners.	Resource-demanding and often complex content elements. Rigid integration with mobile applications. High price.	Most courses are behind a paywall, making licensing expensive. Downloading videos manually.	Courses cannot be created on this platform.

Whilst many digital learning platforms are available, none are optimal for solving this use case, highlighting the need for a tailor-made platform to better suit the needs of the waste pickers. The last cycles of the MEP partnership had also produced a functional application based on the model proposed by Mejer et al. (2020)

for financial education issues of waste pickers. Although the platform was successful in many aspects, the focus of it was to be a financial management tool, missing any kind of learning content inside the App.

As a result of this analysis, feature extraction of the different existing platforms is done, gaining an overview of both the core features of a digital learning application and the specialized features that are well suited to the waste pickers' use case. An example of feature extracted is the Kolibri platforms' use of caching, allowing courses to be cloned from one smartphone to another (Kolibri, 2021). The usefulness of this feature becomes apparent based on the research provided in the article by (Britze & Nielsen, 2019) wherein it is established that the courses would only be downloadable whenever the individual user is connected to Wi-Fi. By implementing the same course cloning structure, it could help alleviate this potential roadblock to entry. With these important notes taken from existing solutions, a summary of conclusions from the problem identification and examination is made.

2.4 Subsidiary conclusions

The problem analysis revealed a clear deficit of education tools for both the waste pickers and other groups with lower socioeconomic status. However, beyond this scarcity of educational options, the waste pickers expressed a high willingness to learn, especially via their smartphones. While their perception on the educational mobile application was by a large majority positive, it's fundamental to understand the specific needs for adapting the tool to the waste pickers learning capabilities, by, for example, incorporating text-to-speech and video materials, enabling those with little to no literacy to also benefit from courses (Britze & Nielsen, 2019, p.19; Mejer et al., 2020, p. 43).

Having established these case specific requirements, the examination of existing solutions led to two different inferences. Firstly, it was found that in person classroom-based teaching had proved somewhat ineffective. Secondly, the currently available products in the market do not meet the learning needs of the target group, highlighting the necessity for a tailor-made solution. With these conclusions reached, the methodology for implementing the solutions for this project is defined.

3 Methodology

After establishing key premises about the problem, the methodologies used to solve it are selected and tailored to fit the project. Since the aim of the research is to solve a problem through Problem Based Learning (PBL), the methodologies for implementing PBL in both universities are discussed. Due to the international nature within a larger cross-disciplinary project, project management and teamwork across fields, universities and groups are examined, showcasing the methodology for cooperative PBL based teamwork within larger projects. Therefore, this section is comprised of three main subsections: Problem Based Learning Methodology; Research Methodology; and International Cross-disciplinary Teamwork methodology.

3.1 Problem based learning methodology

Problem Based Learning (PBL) is a student-centred, collaborative, non-traditional approach to education in which students learn about a subject through the experience of solving an open-ended problem as the main responsible in the learning process (Adderly, 1975; Prince & Felder, 2006; Alfaro, Apaza, Luna-Urquizo, & Rivera, 2019). Specifically, in the engineering area, as part of the applied sciences, PBL appears as a strategic mechanism in training students to apply their knowledge in real problems (Cano, López, & Rebollar, 2008; Habash & Suurtamm, 2010; Tran & Nathan, 2010). This approach guides the students to solutions that require extensive use of soft and interdisciplinary skills (Taajamaa, Kirjavainen, Repokari, Sjöman, Utriainen, & Salakoski, 2013). The PBL experience generates a development for students that goes beyond the understanding of hard skills, generating future professionals with good communication and professional skills, both of them continuously tending to be more required in the labour market. (Deshpande & Huang, 2011).

In this context of active learning, a partnership between the University of Brasilia (UnB) and the Aalborg University (AAU), both learning spaces that empowers the PBL approach, emerged. At UnB, the PBL has been part of the strategy since its conception, which aimed to focus education on real problems as a way to form citizens aware of the challenges of the country and the world (Monteiro et al., 2017). Similarly, since the

founding of Aalborg University, all programmes are problem Based learning centred (Aalborg University, 2021). By having problem based learning so closely integrated within the university, effectively covering half of the curriculum, international interdisciplinary projects focused on concrete solutions, like the one referred in this article, become possible.

3.2 Research Methodology

This article is made as an Exploratory Case Study with qualitative research approach. Starting from the case of the Mobile Education project as the reference experience, it aims to develop hypotheses and propositions in the context of providing education to people of lower socio-economic status. It also explores the results and, finally, outlines possibilities for a future educational paradigm in the context of international collaboration between universities using PBL, especially in the engineering scenario.

The data collected to establish the instructional design and the platform premises was obtained by interviews focused on qualitative questions, applied to 25 waste pickers in their work facilities and 5 cooperative leaders. The questionnaire consists of questions related to interests, feedback, and some other questions to a set of general profile of a waste picker.

3.3 International cross-disciplinary teamwork methodology

The project is comprised of students from two different universities, in two different countries. In Denmark, two computer engineering students from AAU utilized the scope of creating the mobile education app as their Computer Engineering Bachelors Project (CEBP) and were leading an initiative to make feasible a business model to ensure long-term sustainability for the solution. In Brazil, 3 groups also used the creation of this application as project scopes for the main part of their activities in 3 different PBL based courses of the industrial engineering bachelor of UnB: "Production System Project 1" (PSP 1), "Production System Project 2" (PSP 2), "Production System Project 3" (PSP 3) and "Production System Project 5" (PSP 5), each with a singular focus in the development process.

To certify the success of the expected deliverables related to the mobile application, some risks had to be acknowledged and an action plan should be made to diminish the impact of them. The international cross-disciplinary teamwork was a premise of this project, but it was also the main source of risks related to communication, cultural differences, schedule, and others (Table 2).

Table 2. Tasks from each team.

Risks	Action Plan
Limited dedicated time and schedule from students	Early planning of important deliverables and respective delivery dates
Different project expectations from students and professors	Previous expectation alignment between professors and main stakeholders of each country
Language Barriers between the 2 different countries	Establishing selection criteria for the students participating of the international groups, based on the sufficient knowledge of the selected language for communication between teams
Difficulties in communication between team members due to physical distance	Structured methodology for online communication, reporting and documents sharing
Challenges in the alignment between the teams	Structured methodology for integration between projects and their respective stakeholders.

Having analysed the risks, a tailor-made integration and management methodology for the work involving the different teams is made, focusing on minimizing the risks. To apply this methodology, four steps are considered: (i) Division of Responsibilities; (ii) General Alignments; (iii) Setting Project Owners (POs); (iv) Consolidation of Integration Methodology:

Step (i), Division of Responsibilities: Software design and implementation was a central scope as a way to achieve a Minimal Viable Product (MVP), and pilot educational content must be created to allow a sufficient

pilot implementation. Moreover, to ensure the long-term economic sustainability of the project, a business model must be created. Thus, the courses were assigned to each of these necessities (Table 3): CEBP project was defined as responsible for the software design and implementation, PSP2 for researching the problem through interviews and creating pilot educational content, PSP1 for the research of business model viability in Brazil, PSP5 with guaranteeing the quality of all results from PSP2 and PSP3 managing the integration between different teams and stakeholders.

Table 3. Tasks from each team.

Team	Country	Scope
App Developers and Product Owners	Denmark	<ul style="list-style-type: none"> - Design the app functionalities - Implement and deploy the application - Define and align the expected results from the other teams
PSP 1	Brazil	<ul style="list-style-type: none"> - Search for improvements and adaptations of the app's Business Model - Checking for possible financial incomes that fits the Business Model
PSP 2	Brazil	<ul style="list-style-type: none"> - Interview local target market to gather their interests, feedback and general profile - Design the course structure for the app - Detail steps to make a pilot financial course
PSP 3	Brazil	<ul style="list-style-type: none"> - Manage the schedule and time from the project related demands of professors and teams - Control and supply of deliverables and collected data from each team - Report general status of the project to the teams.
PSP 5	Brazil	<ul style="list-style-type: none"> - Use of academic research and quality assessment tools to find improvements in the course structure and content created by the PSP 2 team.

Step (ii), General Alignments: Based on the project responsibilities within Table 3, the research team made alignment meetings with each different Brazilian professor, responsible for the courses, and set the goals for each of the future teams working in the projects related to the international collaboration (Figure 1). The Danish team, working in the CEBP, prescinded alignment since the bachelors' project had beforehand the adequate flexibility to fit the MEP needs.

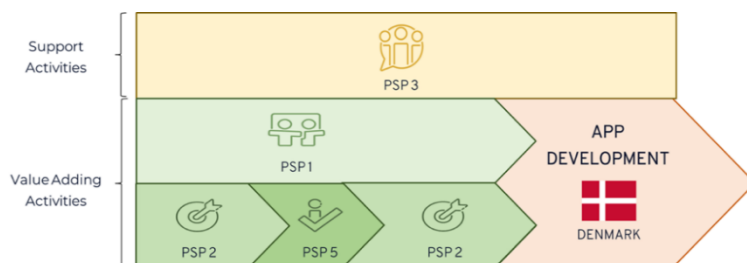


Figure 1. Value chain of the portfolio of projects.

The cooperation and management of deliverables from different teams was a requirement for the project success. The value chain representation was one of the key tools to providing the tailoring of the integration, since, as C.P. Killen & C. Kjaer (2012) described, visual and graphical representation can provide benefits by supporting communication and strategic portfolio decision making.

Step (iii), Setting Project Owners (POs): Besides being responsible for the product design and implementation, the students writing their CEBP from AAU also led the initiative of making a viable business (start-up) based on the digital learning solution. Therefore, they were declared the POs of the entire development.

Step (iv), Consolidation of Integration Methodology: For the transition between the preparation and the practice of the process, an effective integration and management system needed to be developed and communicated (Figure 2).

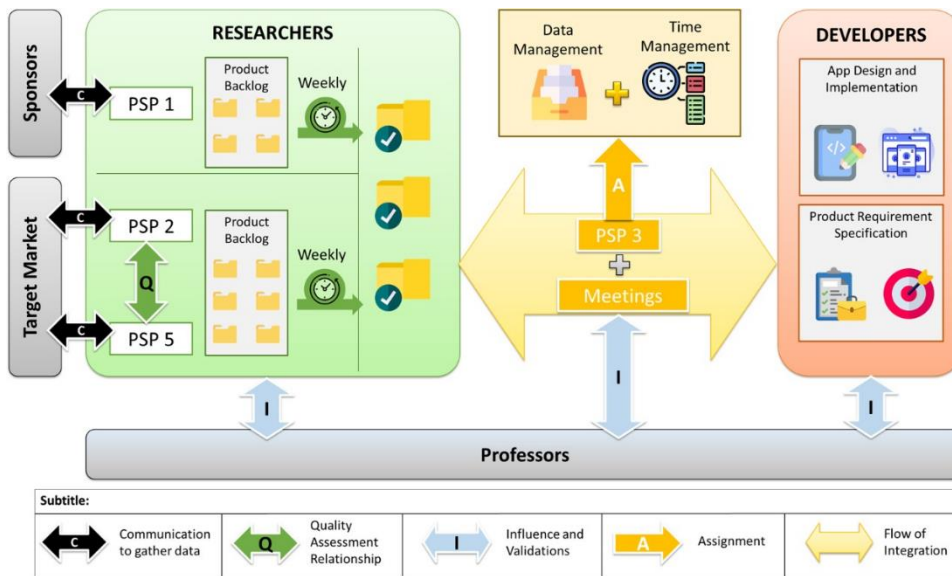


Figure 2. Integration between teams.

Therefore, both the Problem Based Learning Methodology, the Research Methodology and the International Cross-disciplinary Teamwork methodology were defined, and the project, involving different teams, monitors / tutors, product owners, and professors is carried out.

4 Product development and financial strategy

Based on analytical results from user and problem domain research as described in Chapter 2, it is proposed to design and implement a digital learning platform as a distributed web system. The system has two user interfaces – (i) Educado Web, for creating and administering content as well as statistical insights for employers and (ii) Educado Mobile, for smartphone based active learning. During this student project, the ambitions are to develop the Minimal Viable Product (MVP) including both interfaces and connecting them both to a synchronized cloud-based backend handling database and file storage functionality. The general architecture of the system as well as an overview of the applied technologies are systematized (Figure 3).

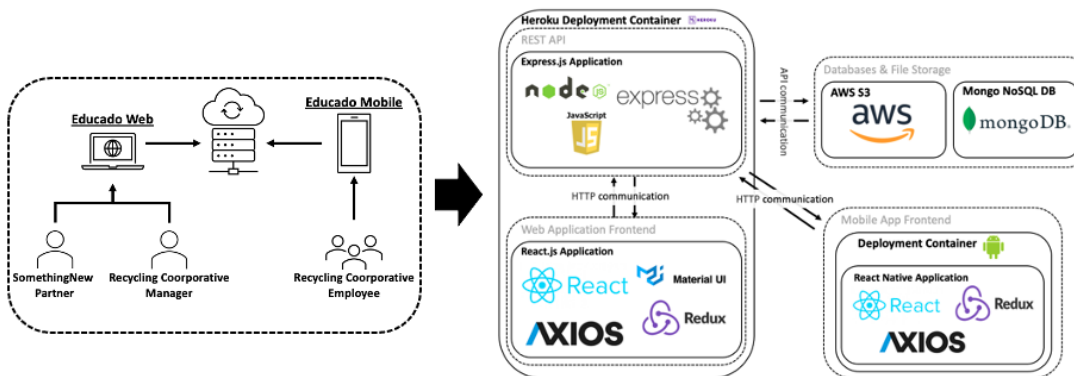


Figure 3. System design.

The system is developed accordingly to engineering principles from Object-Oriented Programming, Structured System Development and Micro-Services software architecture. Design and programmatic decisions are made with prioritization of system maintainability, flexibility, and cost-optimisation. The entire codebase, both backend and frontend sub-systems, consists of JavaScript code and open-source libraries, to keep maintainability costs to a minimum while also creating a flexible framework for further development, as this is important to ensure long-term sustainable use of the product.

4.1 Financial strategy for long-term sustainability as a business

For the solution to achieve long-term sustainable impact, it is necessary to create a viable financial strategy that can support continuous development, project management and maintainability costs. The study driven part of the project is finalized in Q2 of 2021 (Figure 4), whereafter the product ownership is transferred to the engineering start-up company SomethingNew, founded by the AAU participants of the project. Though the project converts to a business-driven development, the cross-disciplinary, user-centred and PBL based frameworks presented in this article are integrated into the project management – and future student projects, are expected to progressively contribute significantly to the project (Figure 4).

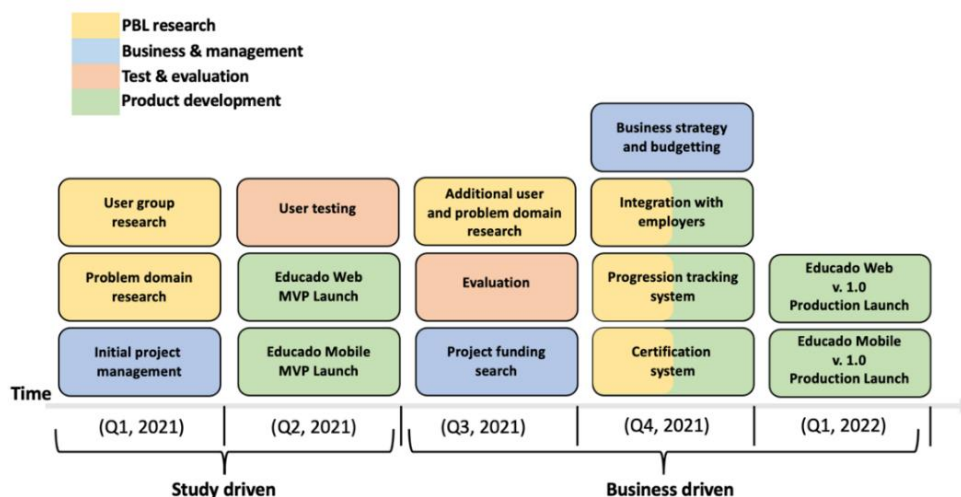


Figure 4. Project planning.

The specific financial strategy of SomethingNew is out of scope of this article, but the expense coverage directly associated with this product is expected to come from both private and public funding. Organisations dedicated to UN's sustainability development goals are expected to support the project through strategic partnerships.

4.2 Course implementation

The creation of an instructional course is accomplished via the learning design methodology, as described by Filatro (2008), which involves four steps: plan, design, execute, measure. This project, carried out by the PSP2 team, is focused on the parts of planning, and designing, which will create the basis for the execution and measuring parts to be carried out in future projects. For the current initiative, a pilot version of the course was developed as a gate between the design step and the future execution step.

The planning step starts by conducting an analysis of the real needs of the users, who, in this case, are the waste pickers. As mentioned in the problem examination, section 2.2, their main educational gap was found to be in financial education, and their basic learning requirements were also defined. Therefore, this section of the article is focused on the following step, which includes the results of the design part.

The course design started with the definition of the teaching sequence, chosen as the following: (a) How to manage your finances and to make your budget (how to plan, register and control the budget), (b) Spending less and saving more (how to stick to the plan, how to avoid making debts, how to save for your future), (c) Investing for the future (where to invest for each goal). Then, aiming at obtaining a problem based learning course, learning situations were developed, which are embodied by a character, who will join the student through the entire course, simulating real-life problems. This strategy not only makes the student closer, by creating identification with the character, but also retains the student during the whole learning process by instigating him/her to figure out how to solve the problems proposed. Finally, for the choice of means and resources, the most important factor is the use of simple words and interspersed procedures with the resources included in the platform, such as short videos, audios segments, simple texts, and clear images.

The design of pilot practical exercises is also a part of the design step and was carried out and integrated in the Educado platform for real world testing with the target group. Therefore, the complete and functional MVP was achieved, as a pilot product for implementation with waste pickers, demonstrating the effectiveness of the MEP international PBL partnership in reaching the established objectives.

5 Conclusion

The platform developed in this project in the context of the Brazil-Denmark partnership matches the waste pickers needs to solve the limitations they face in their learning processes. The Mobile Education app can empower them not only to further evolve their financial lives in their current situation, but also is able to develop new competences to allow them to find other jobs, thus enhancing their conditions for social mobility.

By extrapolating the results of the present work, the future SomethingNew product can create a similar propitious learning environment for different groups in lower socioeconomic situations. Therefore, obtaining a funding model for the philanthropic business initiative that can receive support from various organizations aiming to help different specific groups of people in vulnerability status.

This partnership between Brazil and Denmark evidenced important ways of concrete achievement coming from international cross-disciplinary entrepreneurship in the University context. The Danish team had the computer science skills and the idea of transforming the Mobile Education project in a sustainable business part of SomethingNew, while the Brazilians had closer the business planning and management skills, and closer contact to the waste pickers, a key target group.

As it was effectively applied in this scenario of complexity, involving an international collaboration environment, the methodology for conducting the project proved to be flexible and adaptable for its purposes, elevating the learning potential for the student and creating more value to the stakeholders. Even though the methodology facilitated the job done by the groups involved, there is still a lot of risks related to variable motivation and performance from students, which could eventually become a bottleneck to the whole process if an individual team does not accomplish their assignments, putting at risk the other related projects. The early alignments of expectations and showcase of expected results were vital to the success of the project. Moreover, following the PBL standards, professors and monitors created a free development environment for students, stimulating self-sufficiency for the teams to resolve the problems on their own.

The students reported that the cross-disciplinary approach combined with the interdependency between teams was a key factor of engagement, having provided more motivation than in their previous experiences in the standard PBL methodology. Whilst ratifying the students' perception, professors reported that the methodology applied brought a substantial gain in both the students' attention to quality and their willingness to ask for advice during the semester. The social sustainability-related theme also appeared in the reports as a relevant aspect of the engagement. Both students and professors stated that the high level of interdependence between teams generated some challenges not usually found in the conventional PBL modality, such as managing diverse schedules, communication standards, and types of workflows between different teams. However, they pointed out that their level of learning has grown at a similar rate to the challenge. The authors are aware that there is a balance between on the one hand being motivated through the dependencies among teams, and on the other hand that each group should be able to complete their projects successfully even if other teams do not, therefore each teams' deliverables contribute significantly to the project without compromising other teams in case of potential issues.

The main limitation of this PBL international experience were the restriction due to the pandemic scenario, which prevented face-to-face meetings, adding extra uncertainty to the projects since most data collecting methods relied in interviews and in location observation. Another difficulty experienced was adjusting and fitting the project requirements and schedule with the variable different requirements and schedules of the courses in both universities.

For the next semester of the Mobile Education initiative, the goal is to obtain partnerships with a financial support equal to the running costs and future developments of the platform. Additionally, there is the key aim

of utilizing the UnB-AAU partnership to conduct more projects and research, mainly focused on creating new courses in the platform and testing the quality of the application to ensure the users like using it as well as finding value in the educational content provided.

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