PEDAGOGICAL USE OF CELL PHONES IN CALCULUS I: ADVANTAGES AND DIFFICULTIES

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Abstract

This paper aims at presenting two case studies, with use of cell phones in Calculus I classes, in the first semester of 2011, at a federal institution. Devices belonged to the students, to identify, in real context, advantages and difficulties of such use. Methodology was based on guidelines set by M-learnMat, a pedagogical model to guide m-learning (mobile learning) activities in Mathematics. It was developed by the authors of this paper, based on Activity Theory, and focus on Higher Education. This paper begins by providing an overview of the Activity Theory, and presenting the M-learnMat. This is followed by descriptions of the application of the model, specifying the resources for cell phones used and methodological procedures adopted. The article closes with considerations on the experiment, describing advantages and difficulties of using cell phones. Despite the difficulties, the experience was positive.

Keywords: M-learning, Cell Phones, Calculus, Pedagogical Model.

1. INTRODUCTION

Popularization of cell phones and evolution of technologies associated with them have highlighted these devices in actions related to m-learning[1] (Schmiedl G., Grechenig & Schmiedl B., 2010, Robles, González-Barahona & Fernández-González, 2011, Xie, Zhu & Xia, 2011). In particular, in terms of Mathematics, some studies also have investigated contributions of pedagogical use of these devices (Botzer & Yerushalmy, 2007, Baya'a & Daher, 2009, Nokia, 2009).

In this context, researches on cell phone use in effective educational practices are essential for understanding advantages and difficulties involved. Thus, in the first semester of 2011, two case studies were promoted. Cell phones were used in Calculus I, with two college level groups of students at a federal institution (traditional classroom). Devices used were the students', which allowed a better understanding of the complexity of working with different models of cell phones.

For these case studies, two free applications (apps) were selected, and quizzes to study the topics of Calculus I were prepared. In addition, the virtual environment Moodle was adopted, with MLE-Moodle plugin (which allows extending functionality of that environment to cell phones).

Teaching strategies adopted were based on guidelines set by M-learnMat, which is a pedagogical model for m-learning Mathematics activities. This model, developed with support of the Activity Theory, aims at orienting educational practices that involve the use (non-exclusive) of mobile devices in graduation courses and was developed by the authors of this article.

This paper describes the case studies promoted, reporting advantages and difficulties of the pedagogical use of cell phones, found within the classroom context. Section 2 provides an overview of the Activity Theory, and presents the pedagogical model M-learnMat, who guided the planning of teaching strategies. Section 3 shows a profile of students' cell phones, and describes pedagogical resources used in Calculus I. It also reports methodological procedures adopted in the case studies. Section 4 analyzes advantages and difficulties related to the use of mobile resources. Section 5 closes by presenting final remarks about this study.

[1] M-learning (Mobile Learning) is a field of research that investigates how mobile devices can contribute to learning.

2. M-LEARNMAT PEDAGOGICAL MODEL

M-learnMat[2] is a pedagogical model to guide m-learning activities in Mathematics, for Higher Education. This model allows analyzing aspects related to content and organizational, methodological and technological elements, in favor of pedagogical actions with more defined purposes. Pedagogical actions with a better foundation, clear objectives and organized forms of achieving them can enable a more adequate use of resources, more coherence with the real context and reduction in unpredictable situations. Activities that M-learnMat aims to guide involve the use, non-exclusive, of mobile devices.

The model is based on literature of m-learning (general and related to Mathematics) and concepts of Activity Theory (AT). This theory can be an important methodological resource for planning and analysis of strategies for educational activities in m-learning (Sharples, Taylor & Vavoula, 2005, Uden, 2007). Vygotskian ideas make up the foundation of AT and fundamental principles were established mainly by Leont'ev. The focus is on activities developed by individuals, and on the diverse relations resulting from them. Activity is considered responsible for the mediation between human beings and the reality to be transformed (Leont'ev, 1978).

Activities may vary according to form, method, emotional intensity, time and space requirements, and others. However, the main distinguishing feature of activities is the difference among their motives. Motives may be material or mental, they may be present in perception or, exclusively, in the imagination or thought (Leont'ev, 1978).

As to learning, AT considers it as an activity since it aims at satisfying cognitive needs (Nuñez, 2009). In this approach, formal learning has a social character which goes beyond the individual, as it takes place in active interaction with other people, through collaboration and communication, and mediated by tools and signs (Núñez, 2009). The relationship between an individual and his community is essential for activity (Engeström, 1987). In particular, learning in this approach is a specific type of structured activity, which involves actions and operations directed to a definite object, which the subject is aware (Davydov, 1982).

In addition to TA, the M-learnMat based on Behar (2009), which proposes a framework in which a pedagogical model is composed by a pedagogical architecture (PA) and strategies for its application. Thus, the M-learnMat structure (Figure 1) has an area corresponding to the AP and other related to strategies.

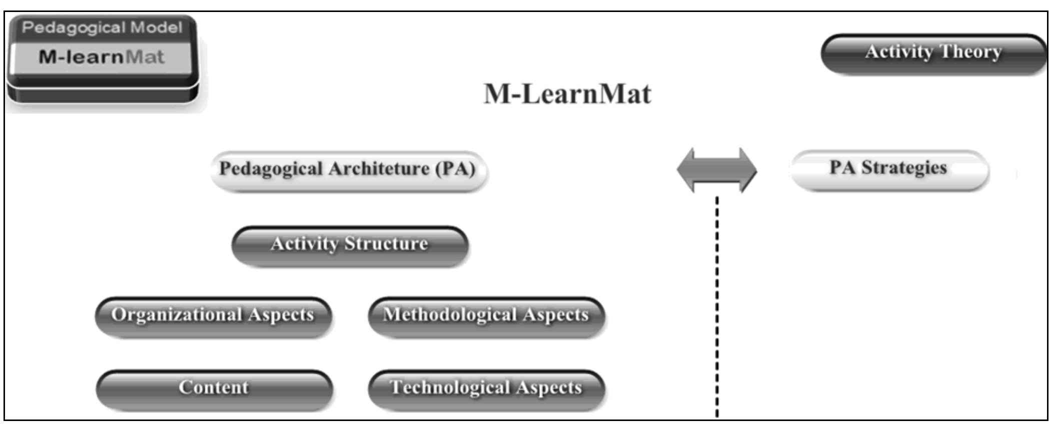

Figure 1. M-learnMat Structure

AP consists of five interrelated elements: i) Structure Activity; ii) Organizational Aspects; iii) Aspects related to Content; iv) Methodological Aspects; v) Technological Aspects. Strategies are ways of putting into practice the issues highlighted in the AP. Therefore, the M-learnMat only provides suggestions for strategies, because they depend on each teacher. This paper does not provide these strategies, but they can be found on the site of the M-learnMat.

In Figure 1, the double arrow between the area of PA and strategies indicates that changes are always possible, even during the development of planned actions, as advocated by Behar (2009).

Activity Structure is the basis for the other elements of the PA. It is an adaptation of Engeström's diagram (1987), which allows us to understand the relationship between the various components of Mathematics activity involving m-learning, in Higher Education. This structure indicates that the relationship between student and mathematical concepts is mediated by tools (including mobile devices) and signs. But in addition, this relationship is also mediated by rules, community and division of labor.

[2] <http://www.nie.iff.edu.br/projetomlearning/index.php?/m-learnmat.html>.

Organizational aspects of PA are related to the preparation of the Mathematics activities to be developed with the support of mobile devices. This includes, for example: i) analysis of the learning context with m-learning; ii) determining the motive of activity and action planning, identifying your goals; iii) setting rules, standards and procedures; iv) definition of roles of participants and technologies adopted; v) analysis of issues related to time and space; vi) definition of issues related to mobility.

Aspects related to the content include, for example: i) identification of requisites; ii) questions about the educational materials to be developed; iii) selection of apps for the device adopted; iv) organization of approaches to best use of the mobile device, aiming at learning.

In M-learnMat, methodological questions are oriented by the AT and, in particular, by Davydov's conceptions (1982). These aspects include: i) issues related to the formation of mathematical thinking; ii) forms of activity's development, iii) evaluation procedures; iv) identification of internal contradictions of the activity (Engeström, 1987).

Technological aspects are related to mobile technology, but not excluding use of other resources. These aspects comprise: i) recognition of the features of the mobile device to be adopted, ii) issues related to the use of mobile devices, including infrastructure, iii) integration of technologies.

M-learnMat can be adapted in order to guide several educational practices, involving different mathematical content and mobile devices. In this paper, we highlight that M-learnMat guided the planning of teaching strategies adopted in the case studies described in the following section.

3. CASE STUDIES: CONTEXT, PEDAGOGICAL RESOURCES AND METHODOLOGICAL PROCEDURES

This section initially presents a profile of the students' cell phones, in order to provide an overview of the context in which the case studies were promoted. Next, it describes the mobile learning resources that support the subject Calculus I and procedures adopted.

3.1 Context's Features: profile of the students' cell phones

Data in this subsection were obtained at the beginning of the first semester of 2011, by questionnaire. These classes were: 1st period of Information Systems, Bachelor's Degree (daytime classes), and 1st period of Systems Analysis and Development, Technologists (evening classes).

The questionnaire had questions related to cell phones, to the use of resources, to their ability of using the keyboard, and to the use of mobile devices in education, among other topics. In the research, 27 bachelor students and 41 technologists answered the questions.

All participants reported having cell phone (regular or smartphone), with predominance of the regular devices, as shown in Table 1. For all the tables in this subsection, 100% of the cells phones corresponding to 27 devices in the case of bachelor students and 41 in technologists classes.

Table 1. Cell Phone: Kinds

Options / Classes	Regular (%)	Smartphone (%)
Bachelor students	74.07	25.93
Technologists	82.93	17.07

Cell phones, therefore, was a popular device among the participants, but few students had smartphones. Thus, although the educational institution in question to grant WI-FI access, few were able to use the same with their devices.

Among the seven smartphones of the bachelor students, there were two different operating systems and among the seven of the technologists, three. How many apps are still specific to certain operating systems, this variation is a factor that may complicate the adoption of an educational app, even in classes where everyone has smartphones. Adoption of Java ME apps can be an alternative to this problem, since many phones have this platform.

The questionnaire also gathered data related to the Java ME platform on students' cell phones. Among the bachelor students, about 70% of the cell phones had such platform and among technologists, this percentage was approximately 61%. Regarding Bluetooth, about 59% of bachelor students' devices and approximately 76% of technologists' cell phones had this technology. Bluetooth can be very useful for transferring files with no costs involved.

Table 2 shows the percentages related to the skill in dealing with the phone's keypad. Categories "Good" and "Excellent", analyzed together, amount to about 59% among bachelor students and approximately 71% among technologists. In educational terms, in general, the percentages obtained were positive, since no one considered his skill as "Awful" and only one student considered as "Bad".

Table 2. Phone Keypad: Skill

Options / Classes	Awful (%)	Bad (%)	Average (%)	Good (%)	Excellent (%)
Bachelor students	0	3.70	37.04	44.44	14.82
Technologists	0	0	29.27	43.90	26.83

Table 3 shows the percentages related to the costs of cell phone use. Question investigated whether this cost was still a limiting factor of use of resources.

Table 3. Costs: Limiting Factor of Cell Phone Use

Options / Classes	Yes	Partly	No	Didn't Answer
Bachelor students	37.04	29.63	22.22	11.11
Technologists	29.27	51.22	12.19	7.32

In Table 3, the categories "Yes" and "Partly", considered together, show that cost, to these students, was a factor influencing the use of the cell phone.

Regarding the use of mobile devices in education, all students were in favor, indicating that this proposal was widely accepted.

3.2 Pedagogical Resources

After analyzing data about cell phones, apps that run on Java ME were sought, to achieve the greatest number of students. Graphing Calculator and Graph2Go were chosen. Both are free, but in English, because apps equivalent in Portuguese were not identified.

Graphing Calculator[3] (Figure 2a) is a graphic scientific calculator that draws the graph of up to three simultaneous equations (2D) and also the graph of functions defined by two sentences. The version used in Calculus I was 0.97.

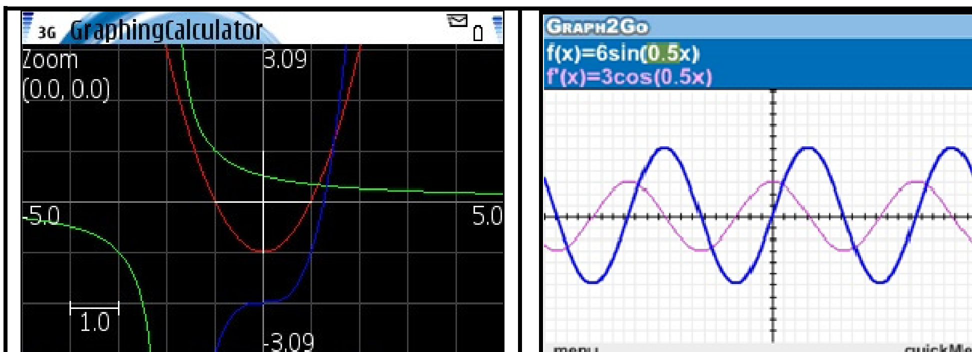

Figura 2ª. Graphing Calculator

Figura 2b. Graph2Go

Figure 2. Apps

Grap2Go (Figure 2b) is an app developed in Math4Mobile, a project of the Institute for Alternatives in Education, affiliated to the University of Haifa, Israel, coordinated by Michal Yerushalmy and Arik Weizman. Graph2Go operates as a graphing calculator for a given set of functions, allowing connections between graphic and algebraic representations, through dynamic changes. This app also allows plotting the derivative function and calculating the area under the curve at a certain interval. The version used was 0.84.

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[3] App developed by Anthony Rich. Available at <http://www.getjar.com/mobile/36442/graphing-Calculator/>.

Besides these apps, the platform Moodle with MLE-Moodle[4] plugin was used. The project Mobile Learning Engine (MLE) started in 2003 as a diploma-thesis by Matthias Meisenberger (MLE-Moodle, 2009). Through this project was subsequently developed the MLE-Moodle, a plugin that enables extending Moodle functions to cell phones.

Access to the MLE-Moodle, by cell phone, can be accomplished in two ways: through the browser or using the MLE Client, a special module to be installed on the cell phone. When installing the MLE plugin, all Moodle courses start to count on these two options. Both require Internet connection, however, installing the MLE Client, the user can download some resources to the cell phone and then access them without the need for Internet connection. In turn, direct access by the browser is more practical.

When the MLE plugin is installed, an editor for creating pedagogical materials can be used by teachers. This editor works within Moodle and allows, for example, create quizzes for cell phones. The quiz is saved to the topic it was created. From this, it can be viewed and replied to MLE-Moodle (via browser or MLE Client) and also in traditional Moodle. Figure 3 shows a quiz seen in the cell phone.

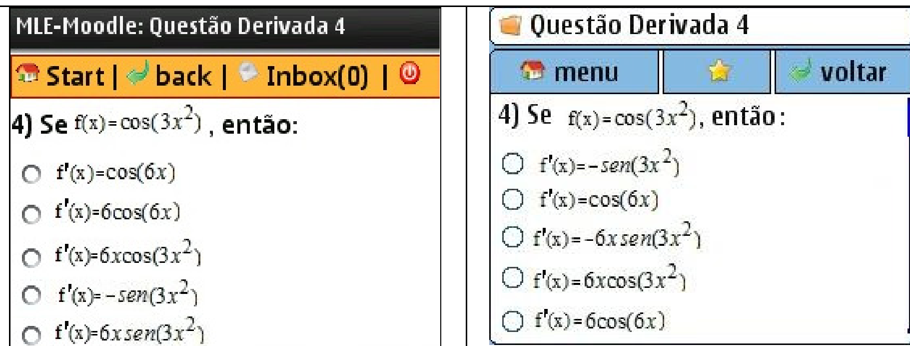

Figure 3a. Phone Browser | Figure 3b. MLE Client

Figure 3. Sample Quiz - MLE-Moodle

The order of the alternatives may change each entry, if the option random is chosen during the development of the quiz. For this reason, in Figures 3a and 3b, the alternatives are in different orders.

In the case studies, the MyMLE[5] was also used. It is a computer program to create quizzes and other pedagogical materials for cell phones with Java ME platform. After preparation, the materials are sent to the cell phones, together with the environment MyMLE (via Bluetooth, for example), and can be used without requiring Internet connection.

3.3 Estratégias Metodológicas

In teaching Calculus I (1st semester of 2011) to two college-level classes at a federal institution, we perform case studies using cell phones. These classes were: 1st period of Information Systems, Bachelor's Degree (daytime classes), and 1st period of Systems Analysis and Development, Technologists (evening classes). Both are conventional classroom courses with the same number of hours (80 h) and content (Limits and Continuity, Derivatives, Integrals).

For data collection, the following techniques were used: observation, registers in the virtual learning environment, and questionnaires. The adopted mobile device was the student's cell phone and virtual learning environment used was Moodle, with the MLE-Moodle plugin. A mixed methods research (quantitative and qualitative) was used due to the characteristics of the data. However, the quantitative analysis used only techniques of Descriptive Statistics. This field of Statistics encompasses a set of methods for the organization and description of data

In addition to the mobile device and the learning environment, several other aspects were common to both classes (content, materials, and group activities, among others). Therefore, it was possible to organize, according to the guidelines of the M-learnMat, a series of common strategies for both courses, such as: i) use of technological resources, especially mobiles, as mediating artifacts – collaborating means to reach the main motive of the discipline; ii) group activities based in problem solving; iii) discussion of the historical origin of each topic (Limits, Derivatives and Integrals); iv) incentive to generalizations, thus contributing to the development of mathematical thinking (the objective is not the solution of specific questions, but the

[4] Mobile Learning Engine – Moodle. <http://mle.sourceforge.net/mlemoodle/index.php?lang=en&page=download.php>.
[5] Free s*oftware,* available in: <http://mle.sourceforge.net/mymle/index.php?lang=en&page=download.php>.

acquisition of tools to solving various questions); v) an understanding that the student is the agent of his learning process, that the teacher acts as mediator, and that the exchange of knowledge among peers is an essential factor.

Mobility, in the discipline described here, was considered in the use of: i) MLE-Moodle resources, which allow access to the course at any time and location; ii) applications for cell phones, which took place in the classroom or not; iii) quizzes which, like the applications, could be accessed from anywhere, and with no need of an Internet connection.

The virtual learning environment Moodle, with MLE-Moodle plugin, increases the possibility of access to course materials and, therefore, contributes to better utilization of students' time. Each topic opens in the Calculus I course in Moodle was always closed with a series of quizzes, so that students could check their knowledge. These quizzes served the function of additional exercises.

However, using the MLE-Moodle requires Internet connection, which not all students had on their cell phones. Thus, the strategy of developing the same quizzes using MyMLE was adopted, so that students who could not use the Internet, using at least quizzes, in addition to apps.

Apps supported group activities based on problem situations, held in the classroom. With the support of the apps, it was more practical to analyze the graphics associated with the proposed questions.

Guidelines to using the apps were available in the Moodle environment, as well as mobile tags (2D codes, similar to bar codes, but with two dimensions) referring to the URLs, in order to facilitate access for those with Internet connection. Students without such connection transferred the apps to the computer and, then, sent them to their phones, via Bluetooth or USB cable, for instance.

Following section promotes an analysis of case studies.

4. PEDAGOGICAL RESOURCES: ADVANTAGES AND DIFFICULTIES

The case studies using students' cell phones, for one semester, indicated real advantages and difficulties associated with such use. However, the context is particular and not allow for generalizations. Despite this, the data shown are relevant because they allow reflections and better planning of other actions in conditions similar to those analyzed.

It is important to note also that, in the beginning of the semester, most students were entering their college program and, therefore, not even feel part of a group, since they were still getting acquainted. Moreover, the contents in Calculus were quite different for them, as they demand a number of pre-requirements and abstractions. Therefore, students had to become familiar with the colleagues, and the pedagogical proposal for the subject Calculus, as well as the methodology, strongly supported on technological resources.

It must be emphasized that 54 of the 68 students who answered the initial questionnaires (around 79%), said they had never used any software for studying Mathematics. Therefore, even typing functions in the Graphing Calculator was a novelty for most learners (even though this kind of typing is similar to most Mathematics computer programs).

After the initial phase (about one month), which included the transfer process and the learning of use of resources, the procedures became more natural. However, as discussed, many devices could not run the apps and quizzes, for lack of Java ME. Also, the Internet, which is a very important tool in educational terms, was not accessible to all. However, these situations are very circumstantial and tend to be minimized with technological advances and falling prices.

It was observed also that in some devices using the Graphing Calculator app was simpler than others, because of features of the keyboard. Entering formulas in the case of this app is a process that can be tiresome, depending on the expression and cell phone model. Thus, ease of use of a resource in the cell phone is not simple to be evaluated, because there is great influence of the device used.

With regard to quizzes, their use was not a very simple process for students who did not have easy access to the Internet. It was necessary to make the transfer and installation of each series of quiz on the cell phone. Thus, in general, students transferred some series available, but not all. For those who could access the mobile Internet, the process was much simpler, using the MLE-Moodle.

Certainly, the case studies also indicated advantages of pedagogical use of cell phones, in formal education:

i) practicality in mathematical investigations, which contributes to reflections, individual and group, on the concepts discussed;

ii) autonomy in the exploration of concepts, which helps the student to take a more active role in their learning and improve their relationship with Mathematics;

iii) better use of time.

However, it is important to consider that some advantages are directly related to the strategies adopted by the teacher.

During the semester, we observe the development of the proposed strategies. In order to obtain other data related to them, a final questionnaire was used and records of Moodle were analyzed. The final questionnaire consisted of 17 statements, on which each student should be positioned in one of the options given: “Strongly agree”, “Agree”, “Neither agree nor disagree”, “Disagree”, “Strongly disagree and Not Applicable”. The option "Not Applicable" (NA) is justified by the fact that not all students have adequate resources on their cell phones and, therefore, might not be able to evaluate all statements of the questionnaire.

In the tables related to final questionnaire, 100% of the participants account for 13 bachelor students, and 26 technologists (total number of students who completed the semester[6]). In this paper, only the statements more directly related to pedagogical use of cell phones are highlighted.

Final questionnaire proposed the following statement: "Apps were relevant resources for the resolution of problem situations." Table 4 presents the results.

Table 4. Apps: Relevance

Options / Classes	Strongly agree (%)	Agree (%)	Neither agree nor disagree (%)	Disagree (%)	Strongly disagree (%)	NA (%)
Bachelor students	30.77	38.46	7.69	23.08	0	0
Technologists	30.77	19.23	15.38	3.85	0	30.77

The percentage of agreement in Table 4 was probably influenced by the fact that not all students were able to use apps on their cell phones. There are 69.23% of bachelor students and 50% of technologists in the options “Strongly agree" and "agree", taken together. The best assessment by bachelor students is probably related to the fact that they were more active in the resolution of problem situations, which were supported by apps.

However, if the analysis is done by the percentage of disagreement, it is observed that only 3.85% of technologists and 23.08% of bachelor students disagreed. Therefore, in general, percentages in Table 4 were positive. They are consistent with the observed reality in the classroom.

Related to ease of use of the apps, the final questionnaire had the following statement: "Apps used in the course were easy to use." Table 5 shows the results obtained.

Table 5. Apps: Ease of Use

Options / Classes	Strongly agree (%)	Agree (%)	Neither agree nor disagree (%)	Disagree (%)	Strongly disagree (%)	NA (%)
Bachelor students	7.69	30.77	30.77	7.69	23.08	0
Technologists	19.23	26.92	19.23	0	0	34.62

Data in Table 5 shows that the percentage of agreement, considering together the options "Strongly agree" and "Agree", did not reach 50% in any of the classes. A significant percentage opted for the alternative “Neither agree nor disagree”. Thus, in the view of students, the ease of use of the apps can still improve. However, as already mentioned, this aspect is very much influenced by the equipment used, therefore, it is impossible to analyze clearly the same. A more rigorous analysis would require testing with similar phone models (which has not been promoted).

Related to the quizzes, the following statement was proposed: "Quizzes were relevant resources for learning content." Table 6 presents the results.

[6] Computer courses (Higher Education) of the institution in question, have problem of evasion, especially the daytime classes.

Table 6. Quizzes: Relevance

Options / Classes	Strongly agree (%)	Agree (%)	Neither agree nor disagree (%)	Disagree (%)	Strongly disagree (%)	NA (%)
Bachelor students	0	30.77	61.54	7.69	0	0
Technologists	15.38	34.62	15.38	3.85	3.85	26.92

Quizzes also required Java ME platform, which not all had. Moreover, while these resources could be accessed at any time and place, they demanded, for many students, a transfer process to the cell phone. Technological evolution tends to minimize technical problems, but the relevance of quizzes for learning should always be reflected, since they have low interactivity and slightly reflect the potential of mobile technologies.

In Table 6, the percentages show that, for technologists, these resources were more relevant than for the bachelor students. This fact is attributed to the context of the class of Technology, which had a greater number of students who felt more comfortable in front of a more conventional proposal, like the quizzes (direct application of the contents studied).

With regard to the practicality of quizzes, the following statement was proposed: "Quizzes are practical resources." Results are shown in Table 7.

Table 7. Quizzes: practicality

Options / Classes	Strongly agree (%)	Agree (%)	Neither agree nor disagree (%)	Disagree (%)	Strongly disagree (%)	NA (%)
Bachelor students	7.70	46.15	46.15	0	0	0
Technologists	11.54	34.61	15.38	3.85	3,85	30.77

Percentages indicate a better agreement rate than the observation, during the semester, it would take to consider, judging by the process of transfer of each block of quizzes (necessary for those who could not use Internet). But, once installed, the quizzes are simple to use. Again, percentages in Tables 6 and 7 on the option "Not Applicable" may be justified by the lack of Java ME on the cell phone.

A joint analysis of the options "Strongly agree" and "agree" in Tables 6 and 7, allows us to observe that the percentage of technologists was slightly larger in the statement about the relevance (50%) than in the aspect practicality (46.15 %). Among bachelor students, the evaluation of the practicality aspect (53.85%) was better than the aspect relevance (30.77%). These percentages are consistent with the characteristics of the classes observed. Some bachelor students had ease with content, as well as skill with technology, which allows us to understand the positions taken. The technologists generally had less time available for study. In this sense, an educational proposal more objective, like the quizzes, assumed a greater importance to them. But at the same time, the transfer of quizzes for those who have not had much time was an additional task.

With regard to access to the MLE-Moodle, the following statement was proposed in the final questionnaire: "Access to the MLE-Moodle on the cell phone, in general, was simple." Table 8 presents the results.

Table 8: MLE-Moodle: Ease of access

Options / Classes	Strongly agree (%)	Agree (%)	Neither agree nor disagree (%)	Disagree (%)	Strongly disagree (%)	NA (%)
Bachelor students	7.69	23.08	38.46	15.39	7.69	7.69
Technologists	7.69	7.69	19.23	3.85	3.85	57.69

Access to the MLE-Moodle demands Internet, which requires devices with resources for that purpose and often involves cost. As mentioned, few students were able to use Wi-Fi provided by the educational institution, due to technological limitations of their devices. The percentage of technologists in option "Not Applicable" is indicative of this situation. The evaluation of this statement may have been too influenced by the cost factor. As shown by the data in Table 3, cost is a factor that also influences the use of resources of cell phone.

Therefore, it was not possible to analyze the usability of the MLE-Moodle, since the evaluation may have involved other factors. Furthermore, analysis of these factors also allows understanding that the data in Table 8, when presenting a low percentage of agreement, reflect the reality of the community considered.

For an overview of the pedagogical use of cell phones, the following statement was proposed in the final questionnaire: "Cell phones were relevant for the study of Calculus I". Table 9 shows the percentages.

Table 9. Cell Phones: Relevance

Options / Classes	Strongly agree (%)	Agree (%)	Neither agree nor disagree (%)	Disagree (%)	Strongly disagree (%)	NA (%)
Bachelor students	30.77	30.77	7.70	15.38	15.38	0
Technologists	34.61	30.77	19.23	0	3.85	11.54

Given the context of two classes, the percentage of Table 9, considering jointly the options "Strongly agree" and "Agree" (61.54% among bachelor students and 65.38% among technologists.) was a good acceptance rate. In general, the technology many cell phones did not contribute to the pedagogical use of the same and thus also the percentage of disagreement is understandable.

4. FINAL CONSIDERATIONS

In Mathematics, digital technologies create possibilities, allowing simulations, visualizations, experiments, among other actions. M-learning adds extra possibilities, such as practicability, mobility, reaching a higher number of people, learning in real contexts, among others. In particular, cell phones have great potential to collaborate to the learning of Mathematics, contributing to views and analysis in a practical way, at any time and place.

In the case studies described, it was observed that the educational use of students' cell phones for educational purposes, under the conditions of the classes considered, it still involves several complicating factors. These difficulties tend to decrease with technological advances and popularization of resources. However, a better understanding of these problems highlights the relevance of the study promoted.

Pedagogical use of cell phones will become more practical with the popularization of smartphones. Devices with many technological limitations restrict, or even make it impossible, such use. However, the choice of apps yet will require care, because some are specific to certain operating systems, do not work in other. Resources that work in various models, such as those that require only the Java ME platform, can contribute to this. The analysis of minimum requirements is, therefore, a key issue for pedagogical use of apps in cell phones, unless a standard device is adopted.

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