ACTA SCIENTIAE

ISSN: 2178-7727
DOI: 10.17648/acta.scientiae.5507

A Didactic Engineering for the development of the Amortization System theme using the HP 12C Calculator Emulator

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Received for publication on 6 Nov. 2019. Accepted after review on 11 Nov. 2019.
Designed editor: Claudia Lisete Oliveira Groenwald

ABSTRACT

This article is an excerpt from the master's research related to a Didactic Engineering with the theme of Constant Amortization System and French Amortization System for the development of didactic situations related to the content of Higher Education Financial Mathematics, and which allows the use of the HP 12C financial calculator emulator. Currently, these amortization systems are being used by Brazilian financial institutions for real estate financing. The objective was to investigate how students of Administration and Accounting apply the mathematical knowledge of amortization in situations by using financial calculators. The methodological approach followed the Didactic Engineering steps, both for the construction of the didactic sequence and for its application and validation. The results indicate that the elaborated didactic sequence contributed to the development of the proposed mathematical content, as well as handling and the ways of dealing with the financial calculators in situations involving the amortization calculations.

Keywords: Mathematics Education; Financial Education; Didactic Engineering; Financial Calculator.

Uma Engenharia Didática para o desenvolvimento da temática Sistema de Amortização utilizando o Emulador da Calculadora HP 12C

RESUMO

Este artigo é um recorte da pesquisa de mestrado relativa a uma Engenharia Didática com o assunto Sistema de Amortização Constante e Sistema Francês de Amortização para o desenvolvimento de situações didáticas relacionadas ao conteúdo de Matemática Financeira do Ensino Superior e, que oportunize a utilização do emulador da calculadora financeira HP 12C. Atualmente, esses sistemas de amortização vêm sendo utilizados por instituições financeiras brasileiras para o financiamento de imóveis. O objetivo foi investigar como os alunos do Ensino Superior de Administração e Ciências Contábeis aplicam os conhecimentos matemáticos, de amortização, em situações problemas com a utilização de calculadoras financeiras. A abordagem metodológica seguiu as etapas da Engenharia Didática, tanto para a construção da sequência

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didática quanto para a aplicação e validação da mesma. Os resultados indicam que a sequência didática elaborada contribuiu para o desenvolvimento do conteúdo matemático proposto, bem como propiciou o contato e as formas de manuseio das calculadoras financeiras em situações que envolvem os cálculos de amortização.

Palavras-chave: Educação Matemática; Educação Financeira; Engenharia Didática; Calculadora Financeira.

INTRODUCTION

Financial Mathematics studies the change in the value of money over time, cash investments, and loan repayments, and is important in the daily lives of management and accounting professionals for decision making, loan negotiations, and other functions (Araújo, 1993).

Sebstad and Cohen (2003) mention that there is a relationship between Financial Mathematics and Financial Education, arguing that Financial Education uses mathematical contents to help when choosing of a financial product, based on the critical analysis of the concepts involved in the product and their respective calculations.

This paper presents a clipping of the master's research about amortization systems using the HP 12C calculator emulator, for the development of didactic activities that allow students to deepen the contents of Financial Mathematics, seeking to broaden the understanding of the importance of Education Financial.

The research problem was: How to develop a didactic sequence involving the contents of Constant Amortization System (SAC) and French Amortization Systems (PRICE) in Higher Education using an HP 12C Financial Calculator Emulator?

To answer this question, the objective of this study was to investigate how the students of the Higher Education Administration and Accounting Sciences, of the Lutheran Institute of Higher Education of Itumbiara, Goiás State, apply the mathematical knowledge, of amortization, in situations with the use of the HP 12C financial calculator emulator.

The research methodology used in this investigation was the Didactic Engineering, because it allowed to organize the research stages and to perform the data validation internally, from the *a priori* and *a posteriori* analyzes.

FINANCIAL EDUCATION

Financial Education is a recent theme, which according to Oliveira and Pessoa (2016) have been gaining evidence in academic and school discussions, because to face an increasingly complex society, either by the great demand for information, or by the change personal relationships and related consumption to lifestyles, it is necessary to insert the theme Financial Education, so that individuals have knowledge regarding how to

deal with money, the "pitfalls" of consumerism, the concepts of want and need, financial products (cards , loans, financing, private pension, etc.), among others.

According to Saito (2007), Financial Education is a theme that has started to arouse interest from International Organizations, among which stands out the Organization for Economic Cooperation and Development (OECD), which conceptualizes Financial Education as a process in which individuals improve their understanding about financial products and their concepts and risks, so that, from information about this area, they can develop the skills needed to make decisions.

Saito (2007) mentions that Financial Education goes beyond the notion of being a simple instrument for obtaining financial information and advice, as it is a process that contributes to the development of knowledge and skills, transforming individuals into critical and informed citizens about financial services as well as prepared to manage their personal finances by avoiding being influenced by the media, often leading to rampant consumption and personal indebtedness.

The author points out that Financial Education can be understood as a process of knowledge building that allows the improvement of the financial capacity of individuals, so that they can make decisions. It also adds that the financial decision-making process involves the following steps: identification and undertaking of personal projects linked to obtaining financial resources; elaboration of strategies to save your financial resources; and put into action actions that result in the correct use of such resources based on your personal planning.

For Sebstad and Cohen (2003), the need to financially educate individuals intensifies with the growth of the microfinance sector (providing loans, savings and other specialized financial services). Currently, in response to market pressures and the financial difficulties that families face throughout their lives, the products of this sector are increasingly being used, whether for housing and education credits, checking accounts, savings, resource transfers and insurance, among others. However, in general, individuals do not understand the specificities of each of the alternatives and, therefore, may misuse them.

In this sense, in order to compare the possibilities that are available to them, individuals need to understand, the characteristics of the various options, how to calculate and compare the costs of each product, as well as to determine their debt capacity, thus avoiding problems resulting from it..

According to Greenspan (2002, p. 2), Financial Education can be important in the sense of:

> [...] provide individuals with the financial knowledge necessary to prepare budgets, initiate savings plans, and make strategic investments to assist in decision making. Financial planning can help families meet their short-term and long-term obligations and maximize their well-being and is especially important for populations that have traditionally been under-served by our financial system.

Sebstad and Cohen (2003) add that there is a relationship between microfinance and Financial Education, because Financial Education can assist in the administration and processes of choosing the former. The author explains that by teaching finance notions about earnings, spending, savings and loans, Financial Education enables people to manage their resources and understand financial options.

In this context, Financial Education can play an important role in helping individuals to manage and preserve their financial resources, as one of the objectives of Financial Education is that people to use concepts of money and how to administer, it to enable them to competence building related of personal finance issues, and also to have the opportunity to gain skills related to the use of money.

In this sense, Maximiano (2003) states that Financial Education involves a range of topics, from cash flow management and risk management, to future planning. The relevance of the themes to a particular case will depend on factors such as: the financial situation and the needs of the individuals or groups involved; your financial landscape; its phase of the life cycle; and other aspects related to the context in which they live and work.

According to Silva and Powell (2013) Financial Education, in the school context, aims to propose a model of a curriculum in personal finance in order to provide a program conception and evaluation criteria that can be used by teachers, school administrators, curriculum specialists, instructional material developers, and educational policy makers.

it is understood that discussing Financial Education is about current issues involving money and our relationship with it. According to Gitman (1997), this will be possible if individuals understand the mathematical concepts that permeate financial operations. For the author, financial operations can be understood through the contents of Financial Mathematics that include mathematical procedures to facilitate monetary operations, knowledge that is essential for the individual to exercise his role as a critical citizen. It is the knowledge of Financial Mathematics that makes it easy, for example, for a person to realize that he is paying an exaggerated interest for a purchase he has made or, if he can make considerable savings through a discount on the purchase in cash product.

However, the contents of Financial Mathematics are necessary to understand the debate about financial capitalism, as they serve as the basis for taking a critical position in the face of facilitated consumption media, so present in the daily lives of our students and future finance professionals. Thus, it is necessary to discuss this theme in the field of Education, aiming at the formation of students with a critical and in-depth knowledge, facing these issues that are present in life in society and in professional life. Thus, it is understood that in the academic environment the Financial Education aims to assist the student in understanding the concepts and calculations of financial products and services for the exercise of their profession, as well as for their use in personal and social life.

TEACHING WITHTECHNOLOGIES

According to Jonas (2006) in the last 50 years the technological revolution has reached the general population. Knowledge has come to be produced with such speed that it is difficult for humans to absorb and assimilate all information. Today, society lives the information age, when relating technological progress with the ease of information, care must be taken in the development of knowledge. All technical innovations are created to facilitate human life, however there must be harmony and above all reflection on the use of technology..

Due to the transformations resulting from information and communication technologies in life in society, it is necessary to update and innovate the school curriculum. The technology in the understanding of Jonas (2006) is ambivalent, that is, in itself does not represent good or evil, but what will characterize its benefits or harms is the way it will be used, for that an ethical look is needed, so you can analyze risks, hazards and threats, seeking to impose the required limits.

According to Aranha (2006, p. 32), education can then be understood as an integrated element in society and "cannot be understood outside a concrete historical-social context and, therefore, social practice is the starting point and the of the arrival of the pedagogical action ". Like, if you are living in a society in which technology is mediating the relationship between information and the human being, educational institutions need to enable training that ensures their proper use.

It cannot be denied, according to Brito and Purification (2008) that technologies provide different possibilities in education, but for this it is necessary that teachers become aware of this reality and use technologies as tools to improve their teaching methodologies. Teachers need to understand the influence of technology in today's world and put it at the service of their students' education and training.

Still Saviani and Duarte (2010) point out that the educator has a significant role in the learning process, because it is he who leads the learner to the experimentation process, introducing mediating resources to overcome limitations, so learning is not conceived as an individual action, but a collective activity between teacher, students and knowledge.

According to Masetto, Moran and Behrens (2000), technologies contribute to the development of education, since the teacher can use them to make the development of the contents to be developed dynamic. The authors expose the pedagogical potentialities of the use of technologies for the development of education, as they modify the dynamics of the classes, allowing students, when well used, the curiosity for knowledge, making the classroom environment promising and making them more promising. they actively participate in the learning process, ceasing to be spectators and becoming active and responsible for their learning.

For this work, the HP 12C calculator was chosen as technology, because according to Shinoda (1998, p. 13), "one should not neglect the usefulness of the features of financial calculators, particularly the HP 12C, which besides being programmable and

the most used in undergraduate science courses". The financial calculator is used to perform financial calculations involving compound interest, rate of return, amortization and other related methods. According to the author, the HP 12C calculator facilitates the resolution of financial calculations, but its use does not exempt those who operate it from understanding the concepts of Financial Mathematics, for example, when calculating the value of a portion to pay, where one has a nominal rate, it is necessary to understand how to find an effective rate, and then to use such a technological apparatus.

Therefore, it is understood that the proper use of computational resources can help to make calculations more agile, just as calculator software, spreadsheets, applications and emulators can also contribute to the qualification of the teaching and learning process student's. These resources being used in a planned way can enable the Financial Mathematics contents to be developed focusing on their applicability and not only on the formulas and procedural contents.

We chose to use the HP 12C calculator emulator because students can download it to their mobile phone for free, giving everyone access to the feature.

RESEARCH METHODOLOGY

The research methodology adopted was Didactic Engineering, developed in France, by Artigue (1995), which is characterized for investigating the theoretical and experimental aspects, considering that theory and practice are interconnected. In addition, the research validation process is internal, based on the comparison between a priori and a posteriori analysis.

According to Pais (2008) Didactic Engineering has two levels: microengineering and macroengineering. The first has as its object the study of a certain subject, seeking to know the complexity of the phenomena that can occur in the classroom. Macroengineering comprises the complexity of microengineering along with aspects related to the teaching and learning process. This research is based on a microengineering, which sought to investigate the study of Financial Mathematics contents addressed in problem situations involving the Amortization System with the use of financial calculators.

The didactic engineering has four phases: preliminary analysis; a priori conception and analysis of didactic engineering situations; experimentation; a posteriori analysis and validation. For Machado (2015, p. 238) the preliminary analyzes refer to "[...] the conception of engineering, are made through considerations on the general didactic theoretical framework and on the didactic knowledge already acquired on the subject in question.". In this phase, a literature review was performed in the database of the CAPES[1] database on research involving Financial Mathematics and the use of financial calculators. Also, it was built the theoretical framework on Financial Education and technologies in

[1] The database of the CAPES it allows to consult the summaries the theses and dissertations defended with postgraduate programs in Brazil.

teaching, aiming to glimpse didactic possibilities for the development of activities that would enable the teaching through situations with problems with the theme under study, seeking to review and expand the mathematical knowledge of the students involved. in Didactic Engineering.

In the next phase, a priori conception and analysis, the didactic variables are delimited which can be: macrodidactic or global that refer to the didactic engineering structure; and microdidactic or local variables, which refer to the structure of an engineering sequence or phase (Artigue, 1995). In this investigation, the macrodidactic variables were the Financial Education theme and the HP 12C financial calculator emulator for the teaching of Mathematics and the microdidactic variables were the Financial Mathematics contents involved in the activities. Also, in this phase were described the characteristics of the situation that is intended to apply, seeking to predict the actions of students and their expected resolution.

The next phase, experimentation is the stage in which one can approximate the practical results with the theoretical foundations. For Pais (2008) in this phase it is necessary to be aware of all events, as they are sources of information that can contribute to the analysis of the object under study. In the research conducted it was considered that for data collection would be used written records of students, observation of the teacher/researcher during the application of Didactic Engineering and questionnaires.

The final phase, a posteriori analysis, seeks to interpret the results of the experimentation phase in Didactic Engineering. However, validation is essentially internal, based on the confrontation between a priori and a posteriori analysis, theoretical foundations, hypotheses, and research problematics (Artigue, 1995).

The a posteriori analysis is focused on the treatment of the information acquired during the application of the didactic sequence, which seeks to investigate if there was validation, comparing the results of the a priori and a posteriori analyzes.

The following are the activities that make up the Didactic Engineering.

DIDACTIC ENGINEERING INVOLVING AMORTIZATION SYSTEMS USING FINANCIAL CALCULATORS

We chose to present the phases separately from the Didactic Engineering developed.

Preliminary analysis phase

This phase began by conducting a literature review in the database of the Higher Education Personnel Improvement Coordination (CAPES) database on national master and doctoral research involving Financial Mathematics, higher education and the use

of financial calculators. Seven dissertations were found that were related to the focus of this research (Table 1).

Table 1
Literature review performed in CAPES database

Author	Adviser Teacher	Job Title	Year	Educational Institution
Silvério Fortunatto	Nilce Fátima Scheffer	Financial Mathematics, Loan Amortization Systems, and Investment Analysis: A Practical Proposal with the HP-12C Calculator	2013	Universidade Regional Integrada do Alto Uruguai e das Missões (URI)
Newton Rodrigues Filho	Frederico da Silva Reis	Using Informational and Communicational Technologies in Mathematics Education: A Study with Undergraduate Students	2012	Universidade Federal de Ouro Preto (UFOP)
Antônio Falcão Neto	José Othon Dantas Lopes	Using the HP-12C Calculator in Commercial Financial Math Operations with an Emphasis on Investment Analysis	2011	Universidade Federal do Ceará (UFC)
Rosane de FátimaWorm	Carmen Teresa Kaiber	Financial Mathematics: a proposal with work projects in Higher Education	2009	Universidade Luterana do Brasil (ULBRA)
Adriano Brandão Feijó	Lori Viali	The teaching of financial math in undergraduate, reflecting on the use of spreadsheet and calculator	2007	Pontifica Universidade Católica do Rio Grande do Sul (PUCRS)
Nelson Dias Leme	Siobhan Victoria Healy	The teaching and learning of financial mathematics using computational tools: a constructionist approach	2007	Pontifica Universidade Católica de São Paulo (PUCSP)
Aparecida Célia Milan	Álvaro José Periotto	The Teaching of Financial Mathematics: A Oriented Approach to Incorporating Technological Resources	2003	Universidade do Oeste Paulista (UNOESTE)

It is concluded that there are few works with the use of technologies for the development of Financial Mathematics contents in Higher Education. Corroborating with Tajra (2000), in recent years access to educational technologies has been expanded, seeking to contribute to the formation of subjects able to work in the labor market and in different situations of daily life, in a technological society. In view of the above, it is understood that it is important to develop the content of Financial Mathematics in Higher Education, for the formation of skills related not only to mathematical content, but also to the use of technology, in contextualized problems and enabling professional knowledge and knowledge. important personal issues for students.

We studied the theme Financial Education and the use of technological resources in teaching, proposing situations related to the content of Financial Mathematics in Higher Education.

A priori conception and analysis phase

The a priori conception and analysis phase was organized in two moments. In the first, as indicated by Artigue (1995), the aim was to elaborate the didactic activities and organize the didactic sequence. In the following moment, the students' actions forecast was elaborated during the resolution process of the elaborated activities.

The following is an example of a proposed didactic activity for the introduction of calculations involving amortization systems, as well as the prediction of students' actions in the resolution process. The activity aims, as Oliveira and Pessoa (2016) promote information on the subject SAC, not only to perform mathematical procedures, but aiming at a Financial Education, in which students can know the concepts and calculations of this amortization system.

According to Sebstad and Cohen (2003) it is necessary to understand the characteristics of each financial product, as well as to know how to calculate its costs. From this perspective, we first sought to provide a didactic situation that could explore each amortization system so that when the students were comparing them had subsidies to perform this analysis.

The activity is: *A bank loans the amount of R $ 10,000.00 with the rate of 10% per month, to be paid in 5 monthly installments, without grace period, calculated by the Constant Amortization System (SAC).*

In this activity students are expected to interpret the problem, seeking to determine what is required; develop a plan to remedy the proposed situation; use the HP-12C financial calculator emulator to calculate interest, amortization, and debit balance on a financing proposal.

The possible actions of the students are:

- First, students are expected to understand what is required in the problem by reading and interpreting the problem situation. For this, students will have to indicate the loan amount, the rate, the amount of installments and analyze if the problem in question will have to be calculated without or with a grace period.
- Next, students are expected to mobilize their mathematical knowledge regarding the amortization system indicated in the proposed problem situation (Table 2).

Table 2
Financial Mathematics using the SAC.

Content	Formulas
Simple Interest (J)	**J = C *i *n,** where C: Capital; i: rate; n: period number; C = SD, where SD: Balance Due
Amortization (A)	**A =** $\frac{PV \text{ ou } SD}{n}$ **,** where PV: Present Value; SD: Balance Due; n: period number
Debt Balance (SD)	**SD = Previous Debt Balance - A,** where A: Amortization
Installment (PMTn)	**PMTn = A + J,** where A: Amortization; J: Interest

The Constant Amortization System (SAC) has as its basic characteristic that principal amortizations are always equal (or constant) throughout the term of the operation. Amortization is obtained by dividing the borrowed capital by the number of installments. Interest, due to the debit balance, whose amount decreases after the payment of each amortization, assume decreasing values in the period.

As a result of the amortization and interest behavior, the SAC's periodic and successive installments are decreasing, in arithmetic progression. The SAC determines that the repayment of principal (borrowed capital) be made in equal installments. Thus, the amount of each depreciation due is calculated by simply dividing the principal and the fixed number of installments.

After understanding the problem, pointing out the unknowns and plotting a plan students can begin the calculation that determines the Amortization portion value (A): $A = \frac{SD}{n} = \frac{10000}{5} = 2000$.

As a second step, students are expected to calculate Interest (J) installments using the formula J = C.i.n (Figura 1).

Calculating Interest:

– Interest for the 1st period: *j* = 10000 • 10% • 1 = 1000,00

– Interest for the 2nd period: *j* = 80000 • 10% • 1 = 800,00

– Interest for the 3rd period: *j* = 60000 • 10% • 1 = 600,00

– Interest for the 4th period: *j* = 40000 • 10% • 1 = 400,00

– Interest for the 5th period: *j* = 20000 • 10% • 1 = 200,00

Figure1. Frame with the interest calculations.

Then they must calculate the outstanding balance (SD) for each period (Figure 2).

Calculating debit balances:

SD = Saldo Devedor Anterior - A

SD = 10000 – 2000 = 8000 for the first period

SD = 8000 – 2000 = 6000 for the second period

SD = 6000 – 2000 = 4000 for the third period

SD = 4000 – 2000 = 2000 for the fourth period

SD = 2000 – 2000 = 0 the fifth period

Figure2. Frame with debt balance calculations.

In addition, students must perform the performance calculation (PMTn), in which the result is expected according to the period given in the situation (Figure 3).

Calculating the installments:

Since the formula is: $PMTn = A + J$, we have:

– PMT = 2.000 + 1.000 = 3.000 for the first period

– PMT = 2.000 + 800 = 2.800 for the second period

– PMT = 2.000 + 600 = 2.600 for the third period

– PMT = 2.000 + 400 = 2.400 for the fourth period

– PMT = 2.000 + 200 = 2.200 for the fifth period

Figure 3. Frame with benefit calculations.

Thus, the financing spreadsheet is prepared (Table 3).

Table3
Activity 1 Funding Worksheet

Period	Debt Balance	Amortization	Interest	Installment
0	10.000,00	-	-	-
1	8.000,00	2.000,00	1.000,00	3.000,00
2	6.000,00	2.000,00	800,00	2.800,00
3	4.000,00	2.000,00	600,00	2.600,00
4	2.000,00	2.000,00	400,00	2.400,00
5	0,00	2.000,00	200,00	2.200,00
Total	-	10.000,00	3.000,00	13.000,00

As Saviani and Duarte (2010) is the teacher who will enable students to contact different resources that can enhance teaching and in this activity can make use of the HP 12C financial calculator emulator, so that students know and know how to use it. .

Moreover, using this resource, besides facilitating the resolution of calculations, can make the development of the mathematical contents approached dynamic (Masetto, Moran, & Behrens, 2000). To solve the activity using the HP 12C Financial Calculator emulator, the procedures are presented in Table 4.

Table 4
Activity developed on the HP 12C calculator emulator.

Enter Data	Key	Enter Data	Key	Display
				
10.000,00		5		2.000,00 (Amortization)
				
10.000,00		10		1.000,00 (Interest)
		2.000,00		**3.000,00** **(1ª Installment)**
				
10.000,00		2.000,00		8.000,00
8.000,00		10		800,00 (Interest)
		2.000,00		**2.800,00** **(2ª Installment)**
				

Enter Data	Key	Enter Data	Key	Display
8.000,00		2.000,00		6.000,00
6.000,00		10		600,00 (Interest)
		2.000,00		**2.600,00 (3ª Installment)**
				
6.000,00		2.000,00		4.000,00
4.000,00		10		400,00 (Interest)
		2.000,00		**2.400,00 (4ª Installment)**
				
4.000,00		2.000,00		2.000,00
2.000,00		10		200,00 (Interest)
		2.000,00		**2.200,00 (5ª Installment)**
	Total of Installmentsparcela			13.000,00

In the development of this activity, it was sought that students develop the concept involved in the constant amortization system so that in professional or personal life situations use it or not, but knowing that this amortization system is constant throughout the period, that interest rates are decreasing, as well as the benefits also decrease, because as indicated by Sebstad and Cohen (2003), Saito (2007), Silva and Powell (2013), Oliveira and Pessoa (2016) it is important to make decisions, having so much mathematical knowledge, how much about finances.

Experimentation Phase

The experiment was applied in the discipline of Financial Mathematics, with 24 undergraduate students in Business Administration and Accounting, from the Lutheran Institute of Higher Education of Itumbiara, Goiás, in the evening shift, in the first semester of 2019.

At this stage, students were first exposed to the research proposal as well as its objective. Afterwards, the students were invited to read and sign the informed consent form presented to the Ethics Committee on Human Research at the Lutheran University of Brazil.

The didactic sequence elaborated with the theme Amortization System using the HP 12C Financial Calculator emulator was organized in the steps presented in Table 5.

Table 5
Organization of the experimental phase meetings

Experimentation Phase Steps		
Steps	**Descriptions**	**Step Objectives**
1	Application of a previous questionnaire[2].	Know the research participants.
2	Research in the physical and / or virtual library about the concepts involved in the study of Amortization Systems.	Research and discuss in the classroom the concepts related to the Amortization System.
3	HP 12C Calculator Emulator Installation.	Download, install and explore HP 12C Calculator emulator commands.
4	Presentation of problem situations 1 and 2 using the calcula HP 12C emulator.	Use the knowledge of Financial Mathematics and the HP 12C calculator emulator to solve problem situations.
5	Contextualized Problem About Buying a Financed Property.	Understand the importance of knowledge of Financial Mathematics for the performance of your profession and for your personal life.
6	Post-Experiment Questionnaire Application[3].	Verify the result of the developed knowledge.

[2] https://docs.google.com/forms/d/1xJrFng5MqW0cPYl8gkyiZCGNQWlzDv74-B4p40nyzs2s/edit
[3] https://docs.google.com/forms/d/1CHHSGunJGvuwG-kajmd560gA4WBEx70SulRjylIvv5A/edit

Post-analysis and validation phase

In this phase we sought to interpret the information obtained in the experimentation phase, in which the students worked in groups, which were named: G1, G2, G3, G4, G5 and G6. In this article, we will present a posteriori analysis and validation regarding the activity presented in the previous phase.

In the activity involving a bank loan of R$ 1000.00, to be calculated by the SAC, it was noticed that the groups were able to solve the activity, as they sought to understand the situation, removing the relevant information, as observed in the resolution of group G1 in Figure 4.

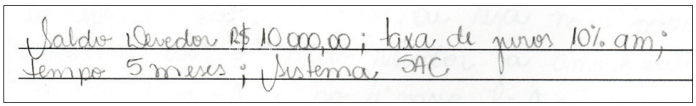

Figure 4. G1 group resolution.

In figure 5, group G1 presents what is to be found during the resolution of the problem situation.

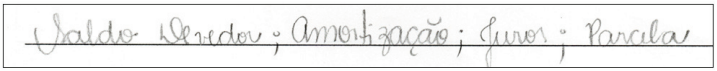

Figure 5. G1 group resolution.

All groups presented a plan to solve the proposed situation, in which the amount to be paid at the end of the established period should be calculated. The option of the students of Groups G4 and G5 was to use the mathematical formulas of the Amortization System with the aid of the scientific calculator to perform the calculations, for this they organized the plan as can be seen in Figure 6.

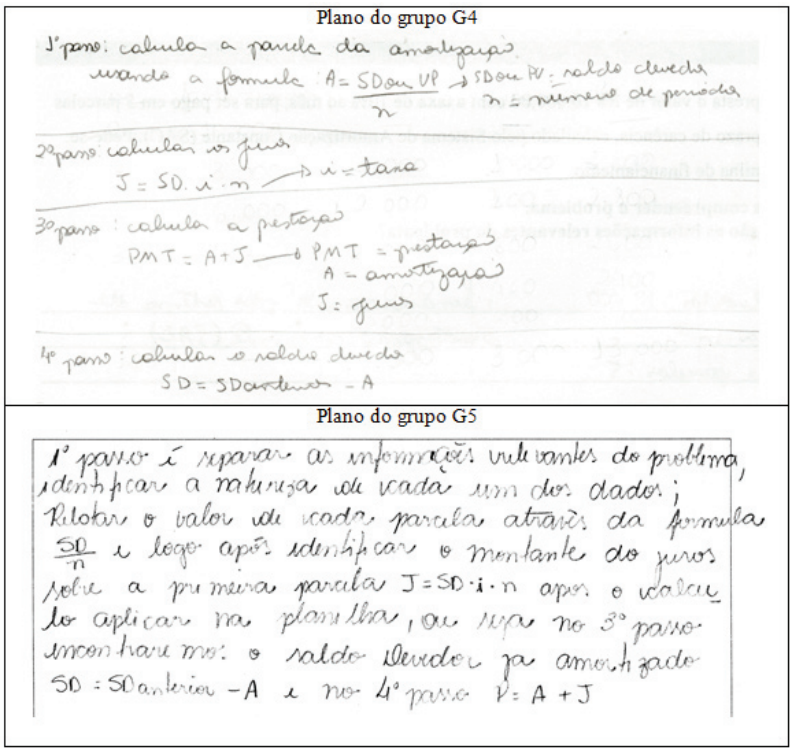

Figure 6. G4 and G5 student planning.

Also during the development of the activity, the G2 Group (Figure 7) provided the content needed to develop the issue.

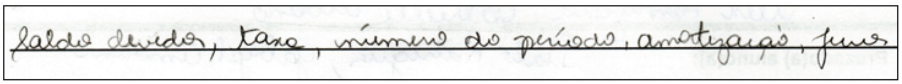

Figure 7. Resolução do grupo G2.

The aspects mentioned so far allow us to infer that students have identified the mathematical concepts related to the SAC, as they are necessary to understand this theme (Gitman, 1997).

Following the activity, group G6 used the HP 12C financial calculator emulator, as shown in Figure 8.

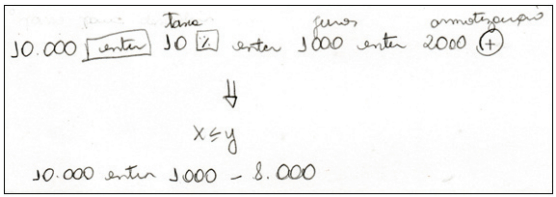

Figure 8. G6 group resolution.

From the collected data and the observations of the teacher / researcher it can be seen that the groups G1, G2, G3 and G6 developed the activity with the help of the HP 12C calculator emulator, on the other hand the groups G4 and G5 used the calculator. because they were used to this feature.

When using the HP 12C calculator emulator, it was noticed that the students correctly performed the procedures for its use, making calculations easier to solve (Shinoda, 1998). What was not foreseen initially was the use of the scientific calculator, but not using the emulator by the students in the process of solving the situation was not a problem, because they were confident in using the chosen resource and were able to develop the activity.

Figure 9 shows the organization of the results obtained by the students of group G3, which identify the amount of the outstanding balance, depreciation, interest and installments for each period.

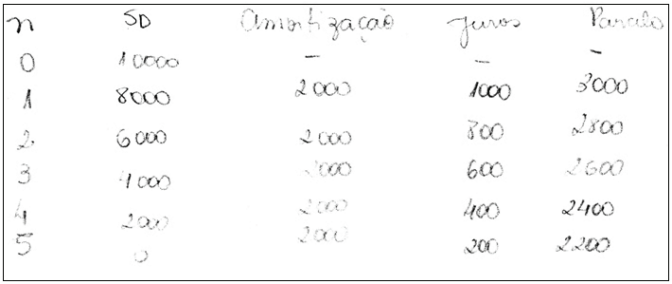

Figure 9. G3 group resolution.

Thus, it is clear that the students used their mathematical knowledge to solve the activity, together with the definitions researched and discussed in the classroom with the teacher / researcher about the constant amortization system.

In the development of activities with the HP 12C calculator emulator, it was noticed the students' involvement in the proposed activities for its use, but in the process of resolution of the proposed situation two groups chose to use the scientific calculator, since they already used it in other undergraduate subjects.

The groups of students who used the HP 12C calculator emulator mentioned that it made it easier to solve the problem, reducing the manual work, and they could discuss about the given situation.

FINAL CONSIDERATIONS

The didactic sequence developed allowed us to deepen the knowledge regarding the constant amortization system and for students to explore the features of the HP 12C financial calculator emulator, facilitating them to solve mathematical calculations. A student's placement in the online questionnaire is noteworthy: *"I concluded that the special functions of the calculated HP 12C emulator are of great value for calculating short and long term financing, as it provides us with precisely what you are looking for"*.

Regarding the use of Didactic Engineering as a research methodology, it was possible to organize the research so that the research steps could be aligned, besides enabling the transition between its phases, allowing the researcher to return to previous stages for adaptations, whenever necessary. .

The analyzes indicated that students used their mathematical knowledge to solve situations involving the subject, using the HP 12C calculator emulator. It was observed that only the choice of technological resources does not allow students to acquire content learning, it is necessary a detailed planning, study and analysis of how to use this resource, as well as elaborate situations that promote discussions and lead to deepening of the approached knowledge.

AUTHOR CONTRIBUTION STATEMENTS

The authors, T.L.M. and C.A.O. wrote, discussed and drafted the version of this scientific article.

DATA AVAILABILITY STATEMENT

The data from this study are only available for consultation through the links: [https://docs.google.com/forms/d/1xJrFng5MqW0cPYl8gkyiZCGNQWlzDv74-B4p40nyzs2s/edit; https://docs.google.com/forms/d/1CHHSGunJGvuwG-kajmd560gA4WBEx70SulRjylIvv5A/edit], mas não podem ser reutilizados.

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