Available online atwww.jlls.org

JOURNAL OF LANGUAGE AND LINGUISTIC STUDIES

ISSN: 1305-578X

Journal of Language and Linguistic Studies, *18*(4), 1178-1185; 2022

Teaching Financial Mathematics With Plausible Reasoning

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APA Citation:

Hurtado, O.G., Casallas, W.P., Thiriat, W.G., (2022). Teaching Financial Mathematics With Plausible Reasoning, Journal of Language and Linguistic Studies, 18(4), 1178-1185
Submission Date: 29/10/2022
Acceptance Date: 26/12/2022

ABSTRACT

This paper aims to show how through plausible reasoning financial mathematics can be taught at the university level, the work is based on a model designed by García (2019), who created it to teach linear algebra in engineering careers, using technology, of all this model, only the design with methodological procedure is adapted. In this grade The theories corresponding to money management will be developed over time, allowing you to obtain a solid foundation in the management and application of simple and compound interest in different financial applications, which will be the prerequisite to continue your studies in financial evaluation of projects. , in which he will use these tools for financial decision making. In addition, this course will implement the use of spreadsheets, to facilitate and expedite the respective calculations, thus giving the student a broad overview and useful resource for their future work performance as a professional.

Keywords: Financial mathematics, plausible reasoning, use of technology.

1. Introduction

This research was carried out in an engineering course at a public university and which is called economic engineering, The objective of the course is that the student is able to implement the basic tools of mathematics applied to finance, through the development of Interpretation, Argumentation and Proposition as cognitive skills, which will show their "know-how" in real situations of their work context and professional performance. To achieve this objective, the didactic proposal called teaching by plausible reasoning was chosen, since the authors already had experience in this methodological proposal, but in other subjects at the university level such as calculus and linear algebra, with very good results. Regarding plausible reasoning, Polya (1966) tells us that a mathematical theorem must be intuited before proving it, as well as the idea of proof before carrying out the details. On the other hand, Lakatos (1976) says:

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2. Methodology.

The methodology used in this research was qualitative since it is the one that is recommended to be used in studies of educational sciences.

The population is all engineering university students who take the subject of financial mathematics or economic engineering.

The sample consisted of 30 students who were studying the Economic Engineering subject at a public university of the Faculty of Engineering in the city of Bogotá, Colombia.

In this course, the teacher implemented the methodological procedure of plausible reasoning taken from García (2019). This consists of giving some theoretical bases and through activities composed of interesting problems the student can get to build the concepts proposed by the teacher. For this, we worked in groups of three students, who developed the activities given by the teacher, the topics were compound interest, annuities and gradients.

3. Implementation and Results

The methodological procedure of this research is taken from García (2109) and given in the following graph:

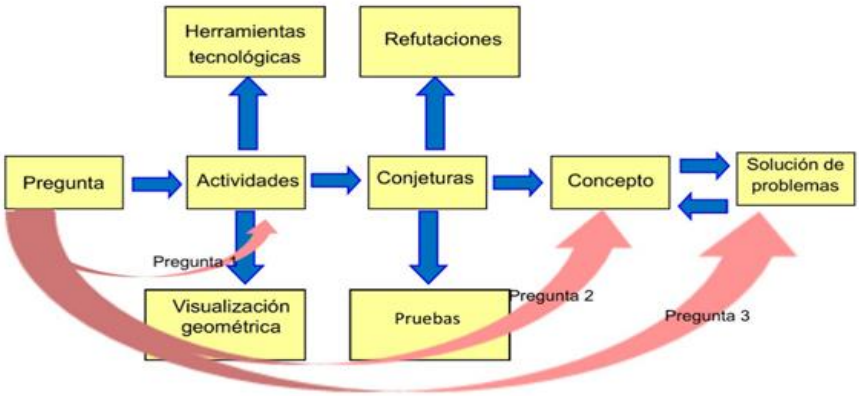

Figure 1. Methodological procedure Source: García (2019)

3.1 Compound Interest.

The objective of this activity is that the student, through routine and non-routine problems with the use of technology for this work, the Excel spreadsheet, could find some laws and properties and solve the proposed problems.

Here are two problems and their respective solutions:

A Financial Entity wishes to refinance the debt to Mr. Ángelo Pulido since he has been repeatedly behind in his payments, the payment plan of Mr. Ángelo Pulido is set out as follows: Payment1 $600,000 on January 30. Payment2 $1,500,000 on February 28. Payment3 $800,000 on August 30. If the gentleman wishes to pay in three equal installments for the last three months of the year in three equal installments, how much should the installments be if they charge him the quarterly nominal 24% in advance?

The purpose of this problem is for the student to find a relationship between money and time on different dates, that is, money loses or gains value at different times, and the interest rate must be consistent with the payment period. and lastly, to do it using technology, for this work Excel, either with the financial functions or by applying the concepts seen in class.

The solution given by a group is:

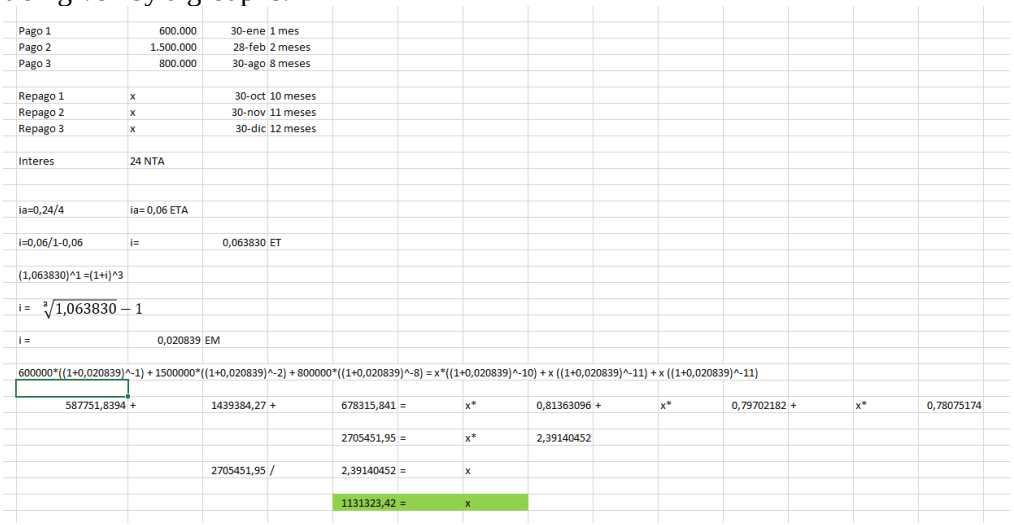

Figure 2. Solution 1

In the solution of this problem it is clearly observed how the students converted the interest rates for the required times and raised the equation that corresponded to the situation raised and then with the help of Excel to find the correct solution.

A person has the following debts: the first for $1,000,000 acquired three months ago and maturing in four months at a rate of 20% CT, another for $3,000,000 acquired today and maturing in 6 months at an effective annual rate of 20%. If they allow you to refinance them for three payments of $2,000,000 in 9, 12, and 15 months, what effective annual interest rate are they charging you?

The objective of this problem is for the student to make a time diagram where, by locating the payments and debts, he will find an equation that, when solved, will be the solution to the problem posed.
Solution given by a group of students:

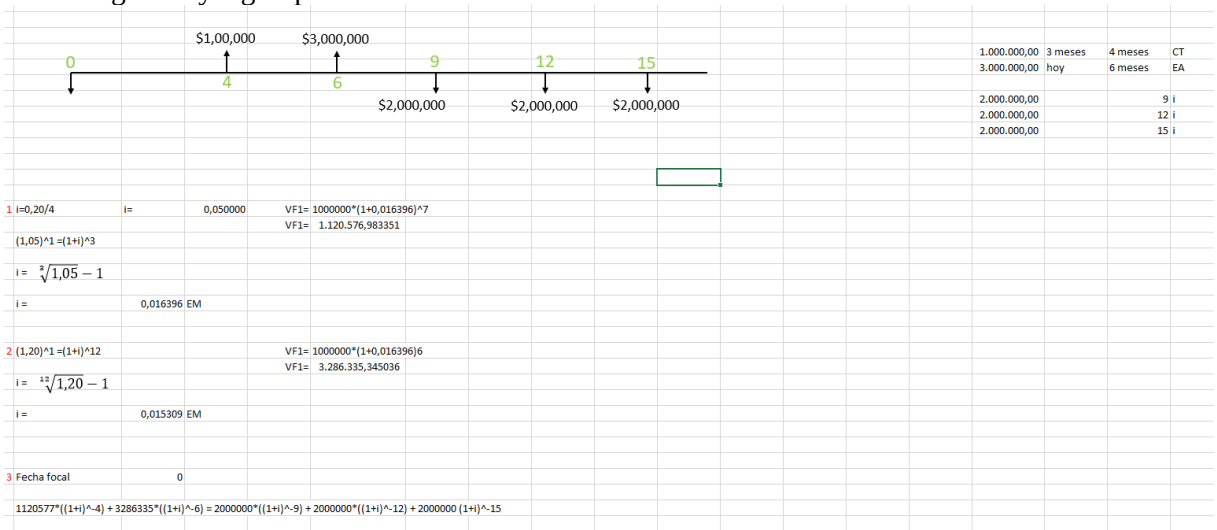

Figure3. Solution 2

It is clearly observed that to solve this problem the students correctly made the required time-value graph and with the help of Excel, they found the indicated solution.

A person receives three offers for the purchase of his property: (a) $40,000,000 cash; (b) $19,000,000 cash and $5,000,000 semi-annual, for 2 ½ years (c) $20,000,000 quarterly in advance for 3 years and a

payment of $2,500,000 at the end of the fourth year. Which offer should you choose if the interest rate is 8% per year? Baca (2000)
The purpose of the problem is that students can find a relationship between a series of uniform payments and the time in which they are made with the current and future value of money, for which two alternatives were proposed.
Solution given by a group of students:

A.	
De contado	40.000.000,00

B.					
De contado		19.000.000			
R		5.000.000	Semestrales		
n	2,5 años			5 semestres	
i	8% anual		(1,08) = (1+i)^2	0,0392	ES
			VP	VF	
	0	19.000.000	19.000.000	19.000.000	
	1	5.000.000	4.811.252	5.196.152	
	2	5.000.000	4.629.630	5.400.000	
	3	5.000.000	4.454.863	5.611.845	
	4	5.000.000	4.286.694	5.832.000	
	5	5.000.000	4.124.873	6.060.792	
			41.307.312	47.100.789	
Respuesta:	La mejor opción es la B ya que en VP da mas de los 40,000,000 que recibira dew contado y al finalizar el ejercicio ganara 47,100,789				

C						
De contado	-				$i\_a=i/(1+i)$	
R	20.000.000	Trimestrales				
n	3 años	10	Trimestres			
i	8% anual	(1,08) = (1+i)^4	0,0194	ET	0,01905635	TA
		VP	VF			
0	-	-	-			
1	20.000.000	19.626.000	20.381.127			
2	20.000.000	19.258.994	20.769.517			
3	20.000.000	18.898.851	21.165.308			
4	20.000.000	18.545.443	21.568.641			
5	20.000.000	18.198.643	21.979.661			
6	20.000.000	17.858.328	22.398.513			
7	20.000.000	17.524.378	22.825.347			
8	20.000.000	17.196.672	23.260.315			
9	20.000.000	16.875.094	23.703.571			
10	20.000.000	16.559.530	24.155.275			
11		-	-			
12		-	-			
13		-	-			
14	2.500.000	1.919.399	3.256.228			
		182.461.332	225.463.502			

Figure4. Solution 3

In this solution it is seen how the students clearly present the payments of each alternative and their relationship with time, then with the help of Excel they find the solution correctly.

A person has proposed to deposit $320 monthly for 2 years (24 months) in a bank account that pays 18% effective annual interest. What will be the cumulative amount at the end of the two years? Baca (2000)
The purpose of the problem is for students to find a rate equivalent to that of the payments and take those payments to future value without using mathematical formulas, only with the concept and use of Excel.
Solution of a group:

R	320			
i	0,18 EA	$\sqrt[12]{1{,}18} - 1$	0,0139	EM
n	24			
	Cuota	VF		
1	320	324,45		
2	320	328,96		
3	320	333,53		
4	320	338,17		
5	320	342,87		
6	320	347,63		
7	320	352,46		
8	320	357,36		
9	320	362,33		
10	320	367,37		
11	320	372,47		
12	320	377,65		
13	320	382,90		
14	320	388,22		
15	320	393,62		
16	320	399,09		
17	320	404,64		
18	320	410,26		
19	320	415,97		
20	320	421,75		
21	320	427,61		
22	320	433,55		
23	320	439,58		
24	320	445,69		
		9168,14		
Respuesta:	La cantidad acomulada durante los dos años es de $9.168,14			

Figure5. Solution 4

This solution clearly demonstrates that the objective of the problem was met, since the students solved it correctly as planned.

A piece of machinery will reach the end of its useful life within 2 years, by that time a new machine to be purchased will cost $9,000,000 and it is estimated that the old machine can be received for the sum of $2,00,000. What quarterly deposit should I make? in an account that pays 30% CM in order to be able to make the purchase at the right time if I make the first deposit at the end of 6 months? Baca (2000)

In this problem, the objective is for the student to find the value of the income in an annuity without using formulas, but only the concept and the spreadsheet.

Solution given by a group:

Interes	30%	CM	0,025	EM	0,07689062	ET					
					0,07689062						
	Compra	Venta	Ahorro								
0											
1											
2											
3											
4											
5											
6			X								
7											
8											
9			X								
10											
11											
12			X								
13											
14											
15			X								
16											
17											
18			X								
19											
20											
21			X								
22											
23											
24	- 9.000.000	2.000.000	X	- 3.870.127,48							
	3.870.127	=	R *	(((1-(1,0768906249999999)^-7))/0,0768906249999999)			*	((1,0768906249999999)^-5)			
	3.870.127	=	R *	5,262198276	*	0,69046556					
	3.870.127	=	R *	3,633366663							
	R	=	3.870.127	/	3,63336666						
	R	=	1.065.163								

Figure6. Solution 5

In the solution of this problem it is clearly seen how the students raise the problem correctly and then with the help of Excel they find the payments that were required for the solution.

Determine the cash value of an asset, if financed, it is acquired as follows: an initial installment of $450,000, 18 equal monthly installments of $40,000 each, and then quarterly installments of $150,000 the first, $160,000 the second, $170,000 the third, and so on until the end of the fourth year; finally six months after the last of these quarterly installments, a payment equivalent to 15% of the cash value. The interest rate is 36% per year. RTA: $1888380.

The objective of this problem is for the student to relate a series of payments with linear growth over time in a specific focal coot.

Solution given by a group of students:

0	450000	450000	450000			544216		
1	40000	40000	40000					
2	40000	38988,0711	41038,1934					
3	40000	38001,7421	42103,3329			136279,863		
4	40000	37040,3656	43196,118					
5	40000	36103,3101	44317,2661					
6	40000	35189,9605	45467,5134					
7	40000	34299,717	46647,6152					
8	40000	33431,9951	47858,3463					
9	40000	32586,225	49100,5018					
10	40000	31761,8514	50374,8972					
11	40000	30958,333	51682,3693		36%	0,36000	EA	
12	40000	30175,1422	53023,7766		8%	0,07990	ET	
13	40000	29411,7647	54400		3%	0,02595	EM	
14	40000	28667,6993	55811,943		15%			
15	40000	27942,4574	57260,5328					
16	40000	27235,5629	58746,7204					
17	40000	26546,5516	60271,4818					
18	40000	25874,971	61835,8182					
19								
20								
21	150000	75098,0595	349400,287					
22		0						
23		0						
24	160000	63606,7576	469360,094					
25		0						
26		0						
27	170000	53663,379	628042,859					
28		0						
29		0						
30	180000	45117,7483	837465,735					
31		0						
32		0						
33	190000	37815,8905	1113274,66					
34		0						
35		0						
36	200000	31607,9657	1475818,33					
37		0						
38		0						
39	210000	26353,0972	1951535,16					
40		0						
41		0						
42	220000	21922,0351	2574743,37					
43								
44								
45								
46								
47								
48	67500	67500	67500					

Figure7. Solution6

It is observed that the students raise the payments correctly and solve the problem with the help of Excel, correctly finding the socuón.

Suppose that we currently have 10 million pesos to invest. One possibility is to create a company that, according to marketing studies, is estimated to yield annual profits of $2,549,000 for 10 years with zero salvage value at the end of this time. We want to know what is the profitability of the project of creating

this company. On the other hand, we also have the opportunity to invest the 10 million pesos in a banking institution that offers us an interest rateof 21% per year.

The purpose of this problem is that the student can choose the best option of two financing alternatives for a given project.

Solution given by a group of students

	Ingresos	Egresos		0,22000607					
0		10000000	-10000000			0	10000000		
1	2549000		2089333,87	2549000		1	10000000	10000000	
2	2549000		1712560,22	3109795,472		2	10000000	12100000	
3	2549000		1403730,9	3793969,353		3	12100000	17715610	
4	2549000		1150593,38	4628665,64		4	17715610	31384283,77	
5	2549000		943104,633	5647000,176		5	31384283,8	67274999,49	
6	2549000		773032,738	6889374,493		6	67274999,5	174494022,7	
7	2549000		633630,239	8405078,699		7	174494023	547636992,4	
8	2549000		519366,464	10254247,03		8	547636992	2079650567	
9	2549000		425708,099	12510243,62		9	2079650567	9555938177	
10	2549000		348939,328	15262573,16		10	9555938177	53130226118	
			-0,12885567	$ 73.049.948	Empresa			$ 53.120.226.118	Banco
				-$ 73.049.947,64					

Figure8. Solution7

It is clearly observed how the students correctly raise the two alternatives and through correct calculations using the spreadsheet they arrive at the best alternative alternative.

4. Conclusions

The research showed that, by applying a set of activities based on a didactic procedure focused on plausible reasoning and the use of technology to solve financial mathematics problems, learning in this subject in engineering careers is significantly improved. Not onlyin conjectures but also in deductions of basic properties of the theory of interest to students. This affirmation is supported by the results of the solutions of the problems carried out by the students.

Attention was paid to the tendencies of the students when developing these activities in the search for arguments that would allow them to conjecture or justify results, without being tied to algorithmic procedures in a mechanical way.

From what was observed in the study, it can be concluded that the use of technology should be used in practices for the development of the programmatic contents of the subject in engineering careers.

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