

Using Mathematical Modelling as an Alternative Assessment to Enhance Students' Financial Literacy

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ABSTRACT

Preliminary studies have found that students have poor financial literacy and lack exposure to real-life problems. Thus, the objective of the study is to find out whether the use of Mathematical Modelling (MM), as a form of alternative assessment, helps Sec 3 Express students enhance their Financial Literacy. During the MM project, students assumed the role of interior designers to furnish a room. *Wikispaces* was used as an ICT platform to facilitate discussion and monitoring. A customized rubric was also uploaded onto *Wikispaces* for guidance and assessment. A quasi experiment and two groups, non-random selection, pre- and post-test test design was used for the study. Results show that MM helps students understand and apply Financial Literacy skills to solve problems by articulating the problem solving process. It also highlighted the importance of Financial Literacy in the real-world context. However, MM may not be useful in helping students remember formulae.

Key words: Alternative assessment, Mathematical Modelling, Financial Literacy

INTRODUCTION

As the Singapore economy grew, the earning capacity of Singaporeans has also increased tremendously over the past decades. However, this gave rise to trend of young Singaporeans who are increasingly ignorant of the value of money. Diagnostic test results have shown that more than half of our Secondary three students had little need to practise their budgeting skills as they could always ask their parents for more money, and almost a quarter of them did not know the importance of saving.

In addition, diagnostic test results also showed that this group of students was unable to articulate their problem solving process. As a result, they were neither able to comprehend more complex problem sums nor present their solutions in a logical manner.

Core concepts of Financial Literacy (FL) such as budgeting, saving, spending, and investing are closely linked with basic mathematical skills as the foundation (Dworsky, 2009; Lipsman, 2004; Lutz, 1999; Roy Morgan Research, 2003; Worthington, 2006).

The importance and relevance of youth FL is becoming ever more critical as both the spending potential and access of young people increase with the increase of affluence in society, such as among Singaporean youth (Bartholomae, Fox, & Lee, 2005).

With the quest for a more applicative type of learning and the pressing need to create an awareness of the above mentioned problems, Mathematical Modelling (MM) was used in this research to cast the students as interior designers to design and furnish a room for their clients; an authentic case problem where they have to plan for their own house in the future. Mathematical Modelling is defined as a process of representing or describing real-world problems mathematically so as to understand or find solutions to the problems (Ang, 2009).

RESEARCH QUESTION

Does the use of Mathematical Modelling as a form of alternative assessment help Secondary three Express students enhance their *Financial Literacy?

*Financial Literacy here refers to budgeting, discount, simple interest, compound interest and hire purchase.

METHOD

Subjects

The sample for this study consisted of 160 secondary three Express stream students. The students were divided into 4 groups [i.e., Groups A (n = 41) and C (n = 35) served as Experimental Group whereas Groups B (n = 42) and D (n = 42) served as Comparison Group].

Design

A quasi-experiment was adopted for this study where classes were kept intact during sampling. A two groups, non-random selection, pre- and post-test test design was used.

Two groups, Nonrandom Selection, Pre-test, Post-test			
Group	Pre-test	Treatment	Post-test
<i>Experimental group = E</i>	O	X	O
<i>Comparison Group = C</i>	O		O

Measure

A set of customised rubrics for the MM project was used by negotiating the various components of the rubrics with the students. This ensured that both students and teachers were clear on the expectations of the MM project and the assessment components. The rubrics also served to guide students on the direction of their MM project by breaking down into different criteria: Goal setting, planning and research, use of mathematics, presentation, aesthetics and quality peer evaluation.

Procedure

The diagnostic and pre-test (see Appendix A) were conducted on both the experimental and comparison groups. After which, the comparison group proceeded with online learning; while the experimental group was briefed on the Mathematical Modelling task.

For the experimental group, the teachers discussed the assessment rubrics with the students, allocated the groups and did a quick demonstration on *Wikispaces*. Each group was randomly assigned a room in a 4-room Housing Development Board flat and the

students had to assume the roles of a team of interior designers. The groups had to design and furnish the room within a given budget, bearing in mind to meet the needs of the profile of their clients. They had to submit an accurate floor plan, a list of furniture they have decided on, purchase scheme for the furniture and a proposal for their clients. The set of rubrics was made available online for the students for self-assessment. Students received feedback from their peers, and made refinement to their projects before the final submission.

Post-test 1 (see Appendix B) and post-test 2 (see Appendix C) were conducted on both the comparison and experimental groups.

RESULTS

The overall results for the pre-, post-test 1 and 2 were obtained and analysed for improvement. A more detailed analysis for the overall results was done based on the method, accuracy and explanation.

Table 1a: Paired sample t-test of pre- and post- tests-1 overall mean scores

Group	Mean		SD		<i>t</i>	df	Sig.
	Pre	Post	Pre	Post			
A	9.88	8.88	4.68	4.36	1.54	40	0.13
B	6.81	6.03	3.97	4.13	1.49	41	0.14
C	4.88	4.81	3.11	3.08	0.11	34	0.49
D	4.30	4.30	3.01	3.67	1.26	41	0.21

Table 1b: Paired sample t-test of pre- and post- tests-1 mean scores in “method”

Group	Mean		SD		<i>t</i>	df	Sig.
	Pre	Post	Pre	Post			
A	6.48	5.63	3.32	3.18	1.62	40	0.11
B	4.18	3.62	2.82	2.83	1.76	41	0.09
C	2.80	2.83	2.51	2.27	-0.06	34	0.95
D	2.42	2.44	2.46	2.82	-0.05	41	0.96

Table 1c: Paired sample t-test of pre- and post- tests-1 mean scores in “accuracy”

Group	Mean		SD		<i>t</i>	df	Sig.
	Pre	Post	Pre	Post			
A	1.50	1.98	0.93	0.70	-3.32	40	0.00
B	1.18	1.49	0.68	1.00	-2.02	41	0.05
C	1.09	0.83	0.51	0.57	2.71	34	0.01
D	1.07	0.77	0.40	0.65	2.47	41	0.02

Table 1d: Paired sample t-test of pre- and post- tests-1 mean scores in “explanation”

Group	Mean		SD		<i>t</i>	df	Sig.
	Pre	Post	Pre	Post			
A	1.90	1.28	1.26	1.24	3.44	40	0.00
B	1.36	0.93	0.99	1.11	2.21	41	0.03
C	0.94	0.74	0.64	1.04	1.13	34	0.27
D	0.81	0.33	0.55	0.75	3.87	41	0.00

Table 2: Independent sample t-test of pre-test and post-test 1 overall mean scores

Group	Mean	SD	<i>t</i>	df	Sig.
A	1	16.87	1.99	81	0.708
B	0.69	9.69			
C	0.07	0.77	1.99	75	0.393
D	9.74	15.90			

As seen in Table 1a, the improvement of the results of post-test 1 made by each group was not significant. This was largely due to insignificant improvement of the method scores (see Table 1b) of post-test 1. However, it was noted that the P-values of accuracy (see Table 1c) and explanation (see Table 1d) showed significant improvements. In addition, Table 2 showed that the experimental groups' post-test results were also not significantly different from their respective comparison group's results.

Upon interviewing some students, it was found that the students in the experimental group could do the questions when the formulae were provided. Hence, post-test 2 was administered.

Table 3a: Independent sample t-test of pre-test and post-test 2 overall mean scores

Group	Mean		SD		<i>t</i>	df	Sig.
	Pre	Post	Pre	Post			
A Vs B	9.88	18.6	4.68	0.847	2.97	81	0.004
	6.81	16.5	3.97	1.36			
C Vs D	4.88	13.9	3.11	1.95	1.81	75	0.747
	4.30	11.4	3.01	2.25			

Table 3b: Mean and Standard Deviation of Method, Accuracy and Explanation of the groups in post-test 2

Components	Group	Mean	SD	<i>t</i>	df	Sig.
Method	A	3.73	0.55	1.37	81	0.17
	B	3.53	0.70			
	C	3.09	1.21	1.06	75	0.29
	D	2.77	1.43			
Accuracy	A	0.95	0.22	2.47	81	0.02
	B	0.77	0.43			
	C	0.45	0.51	0.00	75	1.00
	D	0.45	0.50			
Explanation	A	1.00	0.00	3.80	81	0.00
	B	0.74	0.44			
	C	0.52	0.51	3.99	75	0.00
	D	0.11	0.32			

Group A's overall result is significantly higher than Group B's as Group A's students can obtain the correct final answer at the end of the question (see Tables 3a and 3b). Group C and D's results are not significantly different. However, students from both experimental Groups showed significant improvement for giving the correct explanation for their working without being given specific instructions.

Table 4: Percentage of groups scoring 3 and above based on the rubrics scoring

Group	A (%)	C (%)
Identifying problem, formulating goals and making assumptions	100.0	66.7
Procedure and research	87.5	66.7
Using appropriate calculation and providing a floor plan	50.0	77.8
Presentation of results	62.5	77.8
Aesthetics	62.5	88.9
Peer evaluation	100.0	11.1

* Maximum score for each category of the rubrics is 4

The findings from the online peer and self-evaluated rubrics reveal that the MM project had positive effect on the students' ability to apply the MM process to assess a problem, and later provide ideal solutions and evaluate their feasibility (see Table 4). Most students in Group C however did not refer to the rubrics closely when doing peer evaluation, resulting in much lesser groups achieving good results in this section.

DISCUSSION

Independent-sample t-test on the pre- and post-test 2 shows that MM as an alternative assessment did have an impact on the students' proficiency in the application of knowledge on questions related to budgeting, discount, interest and hire purchase (see Table 3a and 3b).

The alternative assessment also fostered some of the 21st century soft skills that the project aimed to achieve. The students inferred in their rubrics (see Table 4) that they achieved information sourcing and evaluation skills through the procedure in MM process. Besides, they have also learned online collaborative and self-assessment skills through the peer evaluation section of this project.

CONCLUSION

The findings of our research suggest that MM helps students understand and apply Financial Literacy skills to solve problems by articulating their problem solving process. MM also helps to highlight the importance of Financial Literacy in the real-world context. However, MM may not be useful in helping students remember formulae.

The challenge of the MM project is that teacher's intervention is required from the beginning to the end of the project to ensure that students are on the correct path before embarking on the project on their own, and making sure that that the project is in correct order before assessing them.

There were also three identified areas for improvement. Firstly, the timeline for the MM task needs to be shortened to keep students more task-orientated. Secondly, time should be allocated to provide students an opportunity to present their proposals and hone their confidence to present. Lastly, MM concepts could be introduced through pre-MM tasks which are smaller and help students adapt more readily to bigger MM projects.

In conclusion, MM can be used as an alternative assessment to enhance students' financial literacy, but a long term study on the project and refinement of the project is needed to assess and exploit its full potential.

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APPENDIX

Appendix A : Pre-test

1. During the Great Singapore Sale, a pair of jeans was sold at \$140 after a 30% discount. Calculate the price of the pair of jeans before the discount.
2. While shopping for a birthday gift for his mother, a man saw a nice jacket that cost \$120. If the man's budget for the gift is \$100, should he buy the jacket as a gift for his mother? Explain your answer.
3. A couple bought a 5-Room flat for \$560 000. They are required to make a down payment of 20% of the purchase price and decided to loan the remaining amount from the bank. If the couple decided to repay the loaned amount in 30 years at a flat rate of 2.60% per annum, what is the monthly instalment they have to pay the bank?
4. A businessman decides to invest \$60 000 for 5 years, which bank's plan will give him a higher return?

Bank A

Simple interest rate: 2% p.a. first 8 months
and
Simple interest rate: 0.7% p.a. thereafter

Bank B

Compound interest rate: 0.1% p.a. first 6 months compounded monthly
and
Simple interest rate: 0.9% p.a. thereafter

Appendix B: Post-test 1

1. A bag was sold for \$120 and the owner made a 20% profit. Calculate the cost price of the bag.
2. A secondary one student was given \$100 by his parents to purchase his school uniform. If each set of school uniform cost \$15, how many sets of school uniforms should he buy? Support your answer with working and explanation.
3. A car was sold for \$120 000. The buyer had to make a down payment of 30% and take a bank loan for the remaining amount. If the buyer took a bank loan for 10 years at a flat interest rate of 2% per annum, what is the monthly instalment they have to pay the bank?
4. A furniture company offers the following payment schemes. If a buyer bought \$15 000 worth of furniture and wish to repay the loan in 2 years, which payment scheme should the buyer choose? Support your answer with working and explanation.

Payment Scheme A

Simple interest rate: 1% p.a. first 6 months
and
Simple interest rate: 0.5% p.a. thereafter

Payment Scheme B

Compound interest rate: 1% p.a. first 3 months compounded monthly
and
Simple interest rate: 0.5% p.a. thereafter

Appendix C: Post-test 2

Ben plans to buy a computer priced at \$2 500, by a hire and purchase scheme. Based on the scheme, he has to pay a down payment of 10% of the price of the computer and the balance by instalments at a compound interest rate of 5% per annum for 2 years.

- (i) Calculate the monthly instalment Ben has to pay for the computer?
- (ii) If Ben's budget for the monthly instalments in 5(i) is \$100 per month, should he purchase the computer? Support your claim with reasons.