Integration of Spreadsheet into the Teaching and Learning of Financial Mathematics

Chee-Keong Chong
chongck@utar.edu.my
Faculty of Business & Finance
Universiti Tunku Abdul Rahman
Malaysia

Marzita Puteh
marzita@fsmt.upsi.edu.my
Faculty of Science and Mathematics
Sultan Idris Education University
Malaysia

Swee-Choo Goh
goh.sc@fppm.upsi.edu.my
Faculty of Education and Human Development
Sultan Idris Education University
Malaysia

Abstract: *In this paper, we will study the technological integration approach of teaching and learning Financial Mathematics. A sample of 85 undergraduates taking Quantitative Techniques took part in this study. They were taught in Financial Mathematics through the traditional approach in the previous trimester. Pre-test was carried out to find out their performance. Later, they were exposed to spreadsheet approach on the same topic. Then a post-test was administered to assess their performance. Post-test results show significant improvement. A survey was carried out at the same time to determine their perceptions on (i) ease of use in spreadsheet, (ii) the use of spreadsheet template, (iii) awareness on the importance of spreadsheet, and (iv) the urgency in learning spreadsheet. Finally a conceptual model of implementing the integration of spreadsheet into the teaching and learning of Financial Mathematics is proposed.*

1. Introduction

Many business undergraduates face difficulties in mastering basic Financial Mathematics. The reasons being they are weak in basic mathematics and hence most of them develop anxiety toward mathematics. The teaching and learning of Financial Mathematics is never an easy task. With the advent of modern digital technology, it sheds some light on it. Electronic spreadsheet was developed specially for business use but with innovation from mathematics educators its use has been extended to become a pedagogical tool. Although spreadsheet is a useful pedagogical tool for the teaching and learning of Financial Mathematics, its use in universities is still limited because teachers' beliefs on how to teach mathematics were generally affected or influenced by how they learned mathematics [12]. Many mathematics educators limit the use of technology to demonstration, verification, and drill and practice and their knowledge of students' understandings, thinking, and learning in mathematics are confined to mastery of skills only. Spreadsheet can be used to enhance the learning of Financial Mathematics because it is suitable for knowledge construction on its concepts. In order to implement the integration of spreadsheet into the teaching and learning of Financial Mathematics concepts, we need to understand the concepts and knowledge of Technological, Pedagogical, and Content Knowledge (TPACK) [11] possessed by

teachers of mathematics, and also the rational behind the sequencing and prior knowledge on learning mathematics based on Cognitive Load Theory (CLT) [4]. Apart from that the level of acceptance of spreadsheet by undergraduates explained by Technology Acceptance Model (TAM) [5] is also an important factor in determining the success of the integration of technology into teaching and learning of mathematics in general.

2. Literature Review

2.1 Introduction

With the advent of computers, the landscape of teaching and learning mathematics has undergone tremendous changes. Many believe that computers bring more benefits to the teaching and learning of mathematics, because through computer technology many difficult concepts can be visualized easily and this makes the learning of mathematics easier. On top of that tedious calculation on mathematics/statistics can be easily handled by computer software and learners can spend more time on meaningful interpretation of results [3]. One important aspect of introducing digital technology to school is that the emphasis is not on the technology itself but what the technology helps in your teaching and learning. Earle [6] clearly described the integration of technology into teaching and learning:

> "Integrating technology is not about technology – it is primarily about content and effective instructional practices. Technology involves the tools with which we deliver content and implement practices in better ways. Its focus must be on curriculum and learning. Integration is defined not by the amount or type of technology used, but by how and why it is used. (p. 8)"

In order to integrate technology successfully into the teaching and learning of mathematics, it is essential to understand the notion of technology, pedagogy, and content knowledge (TPACK) model put forward by Koehler and Mishra [7]; how to sequence the content with the integration of spreadsheet into it (CLT) [4]; and the understanding of TAM [5] in the adoption of technology into teaching and learning mathematics; as well as the status of spreadsheet use by undergraduates [9].

2.2 Technological Pedagogical and Content Knowledge (TPACK)

Shulman [13] initially introduced the Pedagogical Content Knowledge (PCK). In this model there are two main types of knowledge: content and pedagogy that teachers should acquire. A sound content knowledge coupled with effective delivery method will result in effective teaching. Later, with the introduction of education technology into teaching and learning, another framework has evolved, that is, TPACK. This framework of knowledge model is put forward by Mishra and Koehler [11] to help teachers in integrating technology into teaching and learning. In this model, there are three main components of teachers' knowledge: content, pedagogy, and technology. The successful interaction of these three types of knowledge will result in an effective teaching and learning experience. According to Koehler and Mishra, content knowledge (CK) is teachers' knowledge about the subject matter to be taught to students or learned by students. Pedagogical knowledge (PK) is teachers' own knowledge on teaching and learning methods. Technology knowledge (TK) is knowledge on the effective use on technology to achieve the desired outputs.

TPACK is the resulting interaction of the above three types of knowledge and is the basis of effective teaching with technology [7].

2.3 Technology Acceptance Model (TAM)

TAM was developed by Davis [5] to explain the computer-usage behaviour. There are two important determinants of the actual system used: perceived ease of use (PEOU) and perceived usefulness (PU). On the context of integration of spreadsheet into the teaching and learning of Financial Mathematics concepts, the users (teachers or students) must have perceptions that spreadsheet is useful in helping in the teaching and learning process, as its ease of use they will intend to use it when needs arise. The teachers uphill tasks are to make students aware of its use in future workplace, as well as to ensure students confidence that it is easy to use.

2.4 Cognitive Load Theory (CLT)

The sequencing of contents is an important component of pedagogical skill. Teachers need to introduce the subject matters based on prior knowledge of the learners; from known to unknown; concrete to abstract and easy to difficult. Clarke, Ayres and Sweller [4] pointed out that instruction needs to be developed in a manner that facilitates the acquisition of knowledge in long-term memory while reducing unnecessary demands on working memory to avoid cognitive overload. When integrating technology into teaching and learning, we should try to avoid cognitive overload, otherwise technology will become a burden to students. The sequencing of content knowledge and technological knowledge must be done with care. Clarke et al. [4] found that for students with little knowledge of spreadsheets, sequential instruction on spreadsheets followed by mathematics instruction was better to a concurrent presentation.

2.5 Spreadsheet as Cognitive Tool

Many researchers recognize that computers are cognitive tools and these have no implied intelligence of their own, but rather rely on the user to derive meaning by using the tools to extend his or her capabilities. These tools should not be viewed as crutches, but rather as scaffolds. Unfortunately many use spreadsheet as a productive/utility tool to enhance performance. Spreadsheet can be elevated to become a pedagogical/cognitive tool to help in changing the focus of the classroom from one that is teacher-centered and controlled to one that is learner-centered and open to inquiry, dialogue, and creative thinking on the part of learners as active participants. The use of spreadsheets in teaching and learning financial mathematics is intended to be used as a cognitive/pedagogical tool. Traditional mathematics instruction is defined as instruction that is not supplemented with the use of computer spreadsheets. Traditional instruction could include the use of cognitive tools other than spreadsheets, such as calculators and tables. Mathematically speaking, spreadsheets have considerable potential. They can be used for tabulating functions; graphing functions, statistical analysis, simulation and financial mathematics, in each case requiring some expertise by the user to manipulate the inbuilt spreadsheet functions efficiently to achieve a desired end. Besides that using spreadsheets also promotes higher order thinking skills, promotes the development of problem solving skills and supports “what if…” type questions which are more desirable in this computer age. Computer spreadsheet can be a tool for concept development through situated mathematical problem solving and it is extremely important to have good knowledge of this tool [1, 10].

2.6 Status of Spreadsheet Usage by Undergraduates

A lot of people assume that undergraduates are becoming more computer literate; the results of the survey done by Lim [9] indicated that there is a significant deficiency in the use of spreadsheets. There are a significant proportion of students who are unable to use spreadsheets when they enroll in their universities. Although this study was carried out in Australia, the scenario is no different in Malaysia: many undergraduates are computer literates, and a significant number of them do not know how to use spreadsheets as expected in their undergraduate study. According to The Australian Chamber of Commerce and Industry and the Business Council of Australia, employers of graduates from all disciplines are demanding that their future employees have competency in the use of spreadsheets [15]. Therefore spreadsheet is gradually increasing in its importance as a tool for teaching and learning in primary level up to tertiary level [2]. Students who develop a practical working knowledge of this tool while at school or university then have a skill greatly valued in the business world [14]. Many studies indicate that the use of spreadsheets in workplace is ubiquitous and that graduates find them relatively easy to learn, easy to use and very useful for their work. Spreadsheet skills are considered very valuable. In another study by Kyng & Taylor [8] on postgraduate students and employers support the view that university courses should include training in the use of spreadsheets.

2.7 Proposed Conceptual Framework for the Integration of Spreadsheet

From the literature review, it was found that spreadsheet skills are needed in future workplace of business graduates but the present usage is low [8, 9]. It is timely that it should be integrated into the teaching and learning of Financial Mathematics, not solely because it is a useful utility tool. More importantly it is pedagogical tool that will enhance the teaching and learning of Financial Mathematics. In order to integrate it successfully into the present curriculum, a few model and teaching and learning theories are employed: TPACK, TAM and CLT [4, 5, 11]. Figure 2.7.1 shows the three-stage approach: lecture, tutorial and assignment for the implementation of integrating spreadsheet into teaching and learning of Financial Mathematics. In order not to disturb the present curriculum too much, lecture still follows the traditional approach where most of the teaching and learning are of the expository manner with some introduction of spreadsheet to explain some important concepts like compound interest and annuity. With the use of time-line and spreadsheet, the time-value of money can be shown immediately and this makes learning more effective. Further integration of spreadsheet is done during tutorial and assignment. Tutorials are confined to simple use of spreadsheet which includes a prepared template to determine the variables in loan amortization and the interpretation of the loan amortization schedule. Assignment is a more challenging task that involves mathematical and spreadsheet skills. These will consolidate learning because it involves the construction of concepts through the use of spreadsheet.

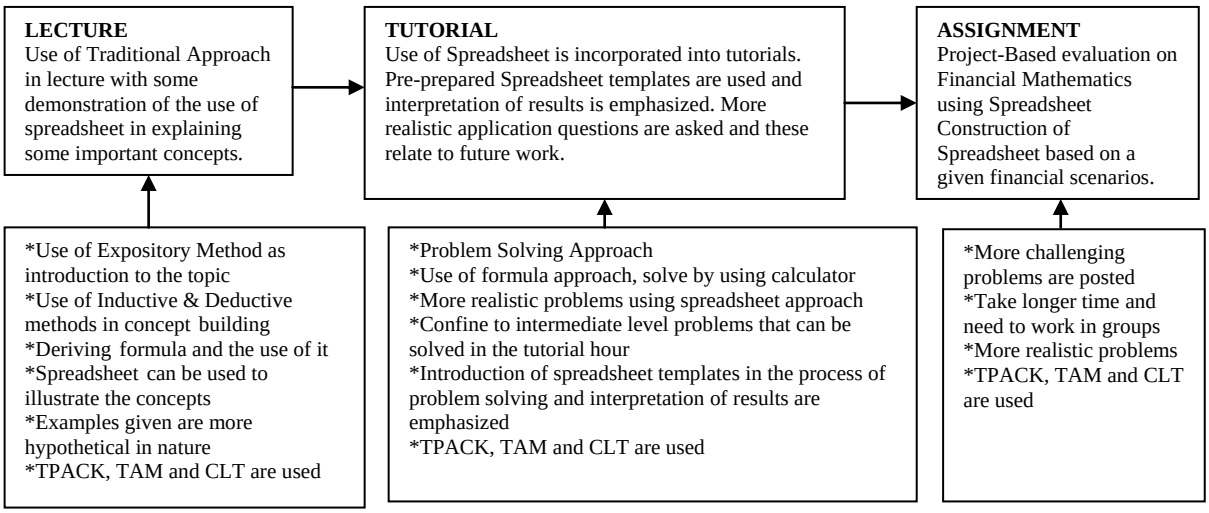

Figure 2.7.1 Conceptual Framework for Integration

3. Research Question

Financial Mathematics is an important component of Business Mathematics. Most of the business students are weak in this topic because they are weak in their algebraic manipulation. With the advent of technology, this topic can be taught and learnt in a better way. This paper intends to answer the research question of "What is the better approach in the teaching and learning of Financial Mathematics from the pedagogical perspective?" In answering this question a conceptual framework is proposed for the smooth implementation of spreadsheet into teaching and learning of Financial Mathematics. A preliminary test is carried out to determine its effectiveness, and perceptions on users are sought for further improvement on the implementation.

4. Methodology

A sample of 85 students who attend Quantitative Techniques II in a local private university was selected for this study. The university was chosen because it has a fair coverage and representative of all undergraduates from Malaysia. There are 1205 students taking this unit in the current trimester and they are organized into 40 tutorial groups. A cluster sampling method was applied to draw this sample since the students in each of these tutorial groups are quite homogeneous. Initially a pre-test was carried out to find out their achievements on Financial Mathematics (which they had completed in the previous trimester in Quantitative Techniques I through traditional method of teaching). They were then exposed to an alternative approach using spreadsheets). After a week students were given a post-test on the same related Financial Mathematics topic with the use of spreadsheet. Students' perceptions on the use of spreadsheets were collected through a survey questionnaire. Results from both tests were analyzed using SPSS.

5. Results and Discussion

There were 85 students taking part in the study. The gender distribution of the respondents shows that 58 (68%) are female and 27 (32%) are male. They are distributed among 7 programme of studies in the university: BBA (Bachelor of Business Administration), BEN (Bachelor of

Entrepreneur), BMK (Bachelor of Marketing), BFN (Bachelor of Finance), BBF (Bachelor of Banking & Finance), BAC (Bachelor of Accounting) and BFE (Bachelor of Financial Economics). Their distributions in the various programme are shown in Table 5.1. The students' achievement in Quantitative Techniques I (in previous trimester) is depicted in Table 5.2. About 40% of them achieved a minimum grade C. Their achievements in this subject were rather low. There are about 18% of them exempted from this unit because they are diploma holders.

Table 5.1 Programme of Study

Programme	Frequency	Percent
BBA	10	11.8
BEN	2	2.4
BMK	6	7.1
BFN	6	7.1
BBF	18	21.2
BAC	39	45.9
BFE	4	4.7

Table 5.2 QT1 Grade Obtained in Previous Trimester

QT I Grade	Frequency	Percent
Exempted	15	17.6
A	13	15.3
B	23	27.1
C	34	40.0

A pre-test was carried out to find out the achievement of students on Financial Mathematics. There are four questions in the pre-test: (i) to calculate the repayment of a loan; (ii) to construct a loan amortization schedule; (iii) use the loan amortization schedule to find the balance of principal after two payments; and (iv) to find the total interest paid. Similar questions were asked in the post-test, except the construction of the loan amortization schedule was replaced by using a spreadsheet template. Tables 5.3-5.8 show the results of pre- and post-tests. There are great improvements on the tasks given. There is a significant difference between the use of traditional approach (pre-test) and the use of spreadsheet approach (post-test). Although there is an improvement on the concept of balance of principal by the use of spreadsheet, the improvement is rather low. It may due to the fact that students did not totally understand the concept of balance of principal. The t-test results (Table 5.4, 5.6 and 5.8) show that there are significant improvements in the post-test.

Table 5.3 Paired Samples Statistics (Pair 1: Amount of Repayment)

	Mean	N	Std. Deviation	Std. Error Mean
Pre-test	.42	85	.497	.054
Post-test	.99	85	.108	.012

Table 5.4 Paired Samples Test (Pair 1: Amount of Repayment)

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% C.I. of the Difference				
				Lower	Upper			
Pre-test Vs Post-test	-.565	.499	.054	-.672	-.457	-10.439	84	.000

Table 5.5 Paired Samples Statistics (Pair 2: Total Interest Paid)

	Mean	N	Std. Deviation	Std. Error Mean
Pre-test	.24	85	.427	.046
Post-test	.92	85	.277	.030

Table 5.6 Paired Samples Test (Pair 2: Total Interest Paid)

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% C.I. of the Difference				
				Lower	Upper			
Pre-test Vs Post-test	-.682	.517	.056	-.794	-.571	-12.176	84	.000

Table 5.7 Paired Samples Statistics (Pair 3: Balance of Principal)

	Mean	N	Std. Deviation	Std. Error Mean
Pre-test	.16	85	.373	.040
Post-test	.42	85	.497	.054

Table 5.8 Paired Samples Test (Pair 3: Balance of Principal)

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% C.I. of the Difference				
				Lower	Upper			
Pre-test Vs Post-test	-.259	.601	.065	-.388	-.129	-3.973	84	.000

The perceptions of students on the use of spreadsheet are positive. About 99% of them think that spreadsheet approach is easier as compared to the traditional approach on the learning of Financial Mathematics (Table 5.9). Besides that about 92% of them are able to use pre-prepared spreadsheet template for their learning. It may be because of the easy learning curve on the use of spreadsheet (Table 5.10). About 94% of the students are aware of the importance of spreadsheet in their future workplaces and moreover there are about 92% of them intend to learn it now (Table 5.11 and 5.12). There is a need to revise the existing curriculum so as to integrate the use of spreadsheet in the teaching and learning of Financial Mathematics. The study also reviews that the level of knowledge on spreadsheet is still very low. About 19% of them do not have knowledge on spreadsheet and a further 73% of them are beginners. Therefore, there is a need to consider to have programme on the

introduction of spreadsheet use before integration of spreadsheet into the Financial Mathematics curriculum.

Table 5.9 Use of Spreadsheet is Easier

	Frequency	Percent
No	1	1.2
Yes	84	98.8

Table 5.10 Are Able to Use Template

	Frequency	Percent
No	7	8.2
Yes	78	91.8

Table 5.11 Aware of the Importance of Spreadsheet

	Frequency	Percent
No	5	5.9
Yes	80	94.1

Table 5.12 Urgency to Learn Spreadsheet

	Frequency	Percent
Now	78	91.8
After Grad.	7	8.2

Table 5.13 Level of Spreadsheet Knowledge

	Frequency	Percent
None	16	18.8
Beginner	62	72.9
Intermediate	7	8.2

5. Conclusion and Recommendation

The above results show that with proper planning guided by sound theories, it could implement change with encouraging results. The suggested conceptual framework in implementing the integration of spreadsheet into the teaching and learning of Financial Mathematics could be a viable one. Further research is needed to refine the needs on the TAM, TPACK and CLT models on this integration model. Apart from PEOU and PU, other determinants may be needed in the refined model of TAM in the integration of technology into the teaching and learning. As for TPACK we need to list out the skills that involve content, pedagogical and technological for future improvement in this model. Finally, sequencing of subject matters and spreadsheet skills needed are important in the pedagogical aspect in teaching and learning. Different spreadsheet skills that match with the specific content should be drawn up for future reference. This study has its limitation because it involves only one private university in Malaysia. In future we could extend the study to include private and public universities in Malaysia, then, the results obtained could be more representative and these could become future reference for policy makers in implementing technology integration in schools or universities.

References

[1] Abramovich, S. (2003). Spreadsheet-enhanced problem solving in context as modeling. *Spreadsheets in Education (eJSiE), 1*(1), 1.

[2] Baker, J., & Sugden, S. J. (2007). Spreadsheets in education–The first 25 years. *Spreadsheets in Education (eJSiE), 1*(1), 2.

[3] Calder, N. (2010). Afforddance of Spreadsheets in Mathematical Investigation: Potentialities for Learning. *Spreadsheets in Education (eJSiE), 3*(3), 4.

[4] Clarke, T., Ayres, P., & Sweller, J. (2005). The impact of sequencing and prior knowledge on learning mathematics through spreadsheet applications. *Educational Technology Research and Development*, *53*(3), 15-24.

[5] Davis, F.D. (1986). A technology acceptance model for empirically testing new end-user information systems: Theory and results. *Doctoral Dissertation*, Sloan School of Management, MIT.

[6] Earle, R. S. (2002). The integration of instructional technology into public education: Promises and challenges. *EDUCATIONAL TECHNOLOGY-SADDLE BROOK THEN ENGLEWOOD CLIFFS NJ-*, *42*(1), 5-13.

[7] Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)?. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60-70.

[8] Kyng, T., & Taylor, P. (2008). Graduates' use of spreadsheet tools in learning and applying financial mathematics. *Asian Social Science*, *4*(3), P66.

[9] Lim, K. (2005). A Survey of First-Year University Students' Ability to use Spreadsheets. *Spreadsheets in Education (eJSiE), 1*(2), 1.

[10] Luderer, B., Weigand, S. & Handrock, S. (2004). Using Computer Programs in Higher Education – Good Practice in Mathematics.
Available at:
http://www.tu-chemnitz.de/mathematik/preprint/2006/PREPRINT_16.pdf

[11] Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *The Teachers College Record*, *108*(6), 1017-1054.

[12] Niess, M. L., Ronau, R. N., Shafer, K. G., Driskell, S. O., Harper, S. R., Johnston, C., & Kersaint, G. (2009). Mathematics teacher TPACK standards and development model. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 4-24.

[13] Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational researcher*, *15*(2), 4-14.

[14] Sugden, S., & Miller, D. (2011). Basic Finance Made Accessible in Excel 2007:"The Big 5, Plus 2". *Spreadsheets in Education (eJSiE)*, *4*(2), 1.

[15] The Australian Chamber of Commerce and Industry and the Business Council of Australia (2002). *Employability Skills for the Future*. Canberra: Department of Education, Science and Training.
Available at: http://www.dest.gov.au/ty/publications/employability_skills/final_report.pdf.