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Formulating a Success Model for Geometers' Sketchpad Implementation in Secondary Mathematics Education

Ramli, R
Senior Lecturer, College of Computer Sciences and Information Technology, Universiti Tenaga Nasional, Malaysia
Che Cob, Z
Senior Lecturer, College of Computer Sciences and Information Technology Universiti Tenaga Nasional, Malaysia
Ali, N
Senior Lecturer, College of Graduate Studies, Universiti Tenaga Nasional, Malaysia

Abstract:
Geometers' Sketchpad (GSP) is selected as one of the official tools for the teaching and learning of technical subjects such as Mathematics in the national education landscape. Though the use of GSP has received a good support from the Ministry of Education, the outcome of its implementation does not necessarily show outstanding results in enabling a more successful teaching and learning of Mathematics at schools. Reports have demonstrated many accounts on GSP being underutilized in the education setup especially at schools. Among the reasons identified is the unwillingness of the main players to use the tools. The teachers are complaining that in using the tools, their workload will be increased to keep updated with the many versions of GSP, the less IT savvy groups of educators are concerned about exposing their inadequacy of handling the technology before their students and the traditionalists who prefer to deliver their teachings in a conventional way may feel their uncomfortable having to change their teaching style. The objective of this study is to construct a success model that can serve as a foundation for a successful implementation of GSP at secondary schools. This result is hoped to provide insights on the factors influencing the success of GSP application in Mathematics education at a secondary school level in Malaysia, which is in agreement with the objectives listed in Malaysia's Education Blueprint 2013-2025 – to leverage ICT in bringing up quality teaching and learning across the nation

Keywords: *21st century skills, teaching and learning, ICT in education, technology acceptance, mathematics education*

1. Introduction

The current employment scenario presents us with the expectation of graduates being job ready and this demand has been very apparent and has triggered shifts and transformation in education system worldwide. 21st century skills among students has fast becoming a popular topic of discussion in the education arena as graduates' job readiness has been tightly associated with the new skills. In addressing the current needs for 21st century skills, it is essential that teaching and learning methods offered are designed to facilitate the integration of the skills, and it is imperative that this is started early enough at the school level. [1]. The 11th Malaysia National Plan has put in its roadmap the proposal to embed knowledge and skills that are 21st century relevant in the school curriculum with the help of ICT. [2]. The plan is also putting in a focus on the delivery of technical subjects such as Science and Mathematics, acknowledging that it is important for students to have good grasp of the subjects.

With IT being pervasive in our lives, it is evident that the use of ICT in teaching and learning has advanced tremendously beyond its initial stage. Over twenty years ago, teaching tools that are IT based was introduced to the education arena and today, teachers have been presented with so many tools and gadgets to support their roles in teaching and learning. The use of ICT in teaching and learning has been seen as an important enabler in producing students with 21st century skills. [3], [4], [5] by presenting students with an avenue to be trained to be equipped as graduates who are IT savvy and good at problem solving.

In 2016, the Education Ministry of Malaysia has signed a memorandum of understanding with Microsoft Malaysia to boost the use of ICT in classroom [6] in line with Education Blueprint 2013-2025 [7] with an objective to make use of ICT in upgrading the level of education delivery nationwide. The use of technology is further strengthened in 2018, where RM190 million has been allocated to implement interactive teaching and learning process using ICT to 2000 classrooms nationwide. [8].

In Malaysia's education scenario, Geometers' Sketchpad (GSP) has been identified and selected as the official teaching tool for technical subjects such as Mathematics both for school and tertiary levels, teachers are encouraged to make use of this tool with 21st Century skills being integrated in the delivery of the subject. However, the state of user's rejection at embracing the use of technology is not spared with the use of GSP. Not unlike the underutilization issues with other technology enabled tools, GSP in the teaching of Mathematics in Malaysia high school is also experiencing its own acceptance and adoption predicament.

This study is investigating the influencing factors in ensuring the success of using GSP in the teaching of technical subject such as Mathematics in Malaysia's schools. Different perspectives are looked into based on the findings from the literatures being reviewed and matched with the existing technology acceptance studies to derive suitable constructs for the success model as an outcome for the study being undertaken. It is hoped that the outcome of this study can be instrumental in providing the recommendation and standard to successfully integrate GSP in the Mathematics teaching and learning at the national schools.

1.1. Problem Statement

GSP has been one of the ICT tools used to support the teaching and learning of technical subjects in Malaysia. At school levels, it has been widely used to support the teaching and learning of subjects Mathematics. Though scores of literatures have made positive accounts on the usefulness of GSP in the teaching of Mathematics at schools [9], [10], [11], [12], [13], there have been suggestions on problems that have led to poor utilization of GSP in the said domain. [1], [9], [10], [14]. Poor utilization will not only result in poor return of investment, but also will hamper the national vision of implementing 21st century education approach through the use of ICT in teaching and learning. Furthermore, the many advantages students could have gained to strengthen both their Mathematical and ICT skills will not be realized if the users are not so keen in using the tool for teaching and learning.

1.2. Objectives

This study is looking into establishing how GSP can be effectively implemented to successfully teach Mathematics at the national secondary schools. Taking into consideration the findings from the literatures studied that have suggested that the underutilization issues are to be addressed not just from the user's perspectives but also from the technical and organizational viewpoints. Therefore, the two main objectives for this research are:

- Recognizing the users' attitudes towards the use of GSP in their teaching and learning activities. The users identified for this study include the teachers, students and the IT technicians at the national secondary schools.
- Understanding technical and organizational factors from the school's infrastructure and administration perspectives towards utilizing GSP as part of teaching and learning requirements.

2. Literature Review

2.1. Reason for Mathematics

Subject Mathematics at the secondary school level is chosen as the focus of this study as this subject is one of the prerequisite sets for most entry requirements for tertiary level education. It is imperative that students demonstrate a strong aptitude in this subject hence there is a need to continue improving the methods for subject delivery. [18], [15], [19] Though this subject has been acknowledged to be one of the important subjects to ensure students' ability to progress to the next academic level, Mathematics has remained to be one of the subjects to be apprehensive about among students. This can lead to 'Mathematics anxiety' which already is a phenomenon among students today, both at school and university levels. [2], [21], [22]. Therefore, it is imperative that ways are explored to see that the subject can be innovatively taught in order to overcome the issues.

2.2. Geometer Sketchpad

Geometer's Sketchpad (GSP) is a Mathematical software for creating, exploring, and analyzing a wide range of Mathematics concepts in the field of algebra, geometry, trigonometry, and calculus. Geometers' Sketchpad (GSP) has been used for years in supporting the teaching of technical subjects at all levels worldwide. Throughout the decades, empirical studies have shown positive outcomes from the use of this tool [9], [10], [11], [12], [13]. In Malaysia, schools have been utilizing Geometers' Sketchpad (GSP) as one of the main teaching tools in supporting the teaching of technical subjects such as Mathematics. [18], [15], [10], [23].Though the use of GSP has received a good support from the Ministry of Education through the acquiring of licenses and training [18], [15], the outcome of its implementation does not necessarily show outstanding results in enabling a more successful teaching and learning of Mathematics. Reports have demonstrated many accounts on GSP being underutilized in the education setup especially at schools. [15], [23], [9], [10], [14] suggesting there are issues that need to be addressed.

2.3. Factors for Underutilization of GSP at School

Among the reasons identified for the poor utilization of GSP are the reluctance of the main players to adopt the tools as part of the teaching and learning activities. [9], [10]. Empirical studies show that teachers complain that using GSP adds more to their teaching load as they have to learn and stay updated with the many versions of the tools. [15], [23], [9]. Ramli [15] suggested that the reason for teachers' being reluctant may be due to the reason that they believe in taking up GSP, they will be delayed in performing their duties as they need to make time for learning and designing the

integration of GSP into the syllabus. In addition to that, the fact that Malaysia's education culture being exam-oriented [16], [17], has added more to the refusal to consider GSP among the teachers. Ramli [15] asserted that the teachers are pressured to ensure that the syllabus is completed on time before the end of the semester, and this has left very little time for learning new things such as ICT tools to support their delivery of syllabus.

Ramli [15] has also investigated students attitudes towards accepting GSP as teaching and learning tool and found that the acceptance of the tool to have been affected by the students' IT competency and sharing the same concerns with their teachers, the students are also worried that their learning time will be prolonged if they were to use GSP, which will add more to the efforts required in securing good grades.

In other studies, teachers highlighted problems in using the tool due to limited understanding and knowledge of the tool [24]. The technology phobic teachers may feel apprehensive with the possibility that they may be showing their inadequacy of IT knowledge to their students [25]. This calls for some organization direction where proper training and technical support should be put in place to assist the users.

Another factor found to be contributing to the success of GSP implementation is the need for an ICT policy [5] to assist in governing the implementation of the tool at the schools, as students may get carried away with the tool and the facilities which may result in distraction and sidetracking. Like any other offering of technology in organization, a sound IT infrastructure to accommodate the hardware and software as well as capable technical staff to providing technical support are important. This is in order to ensure smooth and efficient usage of the technology.

3. Model Development

Research on technology acceptance that focuses on users' attitudes towards technology acceptance have dated back to at least twenty years. Numerous models have been formulated to investigate the various reasons that support and inhibit technology acceptance among users [27]. Among the earliest studies on technology acceptance was Davies' Technology Acceptance Model which has been widely used in many studies of technology acceptance in various domains. Other researchers have improved and extended the model to further develop its applicability for different set-up [28]. The current study will make use of the original TAM model to study users' behaviour and attitudes towards the use of GSP in Mathematics teaching and learning process at secondary schools. This is in response to this model being extensively used in many studies within the educational context [19], [30], [31] From TAM model, two constructs have been identified to be very appropriate to be used in the study of GSP implementation. They are perceived ease of use and perceived usefulness. The former one suggests that users are inclined to make use of ICT tool based on the believe that the tool is easy to use. Perceived usefulness suggests that users will think that the technology is actually beneficial and would support the task they have in hands, both constructs are very relevant in investigating teachers and students' attitudes in accepting and using Geometer's Sketchpad (GSP).

To address the organizational needs in this study, the Technology Organizational and Environment framework (TOE) by Tornaztky [32] is identified as the base of this research for the usability of its constructs in supporting the investigation with regard to how ready an organization is in adopting technology. The TOE framework is looking at technological implementation from three standpoints, namely technological, organizational, and environmental perspectives. All three perspectives are applicable in investigating the implementation of a teaching tool in educational platform as have been demonstrated in studies by Bhati et.al [33], [34].

Technological perspective refers to the technical applications used in the organization, in this case Geometers' Sketchpad, organizational perspective focuses on the school administration and its resources, and environmental viewpoints refers to the government policies such as directive and policies that comes from the Malaysia's Ministry of Education. Summary of the base models and constructs identified for the GSP success model is shown in Table 1 and some excerpts from the findings in the literature review on the use of GSP is listed against the identified constructs for further investigation is listed in table 2.

Construct	Description in relation to the domain	Adapted from Models/Theories
Perceived Usefulness	Describing how useful the users of GSP think the tool is in supporting the teaching and learning of Mathematics	Davis' Technology Acceptance Model (1989)
Perceived Ease of Use	Describing how easy it is the users perceived the use of GSP	Davis' Technology Acceptance Model (1989)
Technology	Being GSP as the tool to be integrated into the teaching and learning activities	Tornatzky's Technology, Organization and Environment Framework
Organization	Being the school as the place where GSP will be deployed and administered.	Tornatzky's Technology, Organization and Environment Framework
Environment	Being the government and national policy and direction for education system	Tornatzky's Technology, Organization and Environment Framework

Table 1: Summary of Based Models/Framework and Constructs for GSP Success Model

Studies	Issues/findings on using GSP at school	Suggested Constructs for Further Investigation
Meng et al. (2011)	Teachers are feeling unsure about their skill in using GSP to teach	Perceived Ease of Use (Davis' TAM)
	Overloaded with administrative and teaching task	Organization (Tornatzky TOE)
	A need to have administrators' support for planning the teachers timetable to include free time for the training of GSP	Organization (Tornatzky TOE)
	Lack of technical support, hardware not working	Technology (Tornatzky TOE)
Ramli et al. (2015)	Teachers are concerned about hardware and software failure.	Technology (Tornatzky TOE)
	Teachers needs commitment for technical support from school	Organization (Tornatzky TOE)
	Teachers want formal training to learn the use of GSP	Organization (Tornatzky TOE)
	A framework that can be applied by schools in promoting the successful implementation of teaching Mathematics with GSP is needed	Environment (Tornatzky TOE)
	The use of GSP in teaching can provide a solution to teachers being absent, where students can use the tool for unsupervised teaching and learning session	Perceived Usefulness (Davis' TAM)
Almeqdadi (2000)	GSP in teaching and learning mathematics is useful to create a positive educational process	Perceived Usefulness (Davis' TAM)
Abdullah et al (2014)	Lack of reference on teaching Mathematics subject with the aid from the GSP software	Environment (Tornatzky TOE)

Table 2: List of Findings on GSP Use against the Identified Constructs For the Success Model

3.1. The Proposed Model

This study has established constructs for a Geometric Sketchpad implementation is Malaysia's secondary school and they are integrated in a form of a success model as shown in Figure 1.

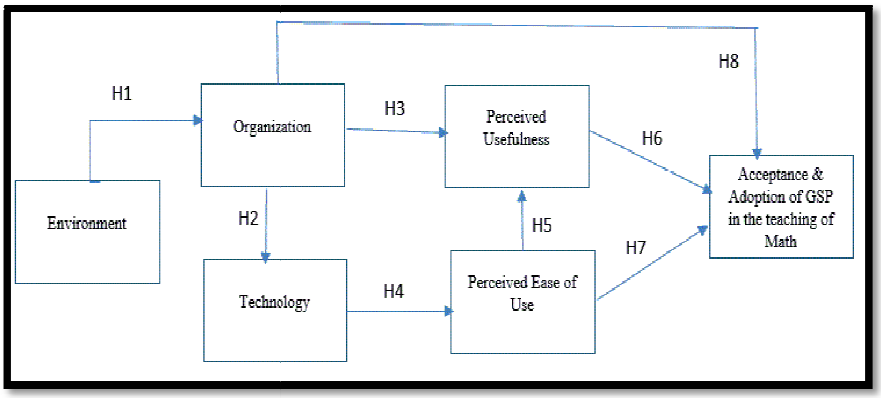

Figure 1: A Proposed Integrated Success Model for Geometers' Sketchpad (GSP) Implementation in Malaysia Secondary School

The Hypothesis drawn for this model is as follows:

- H1. Higher needs for graduates with 21st century skills will result in higher utilization of ICT in teaching and learning at school (organization)
- H2 Higher level of organization's awareness on the use of ICT in supporting 21st century education will result in higher prospect in implementing GSP as teaching tool
- H3. Higher level of support and involvement on the use of GSP from the school management will result in higher perceive of usefulness among the users.
- H4. Higher quality of the ICT tool (GSP) will result in higher perceived ease of use among the users.
- H5. Higher perceived ease of use will result in higher perceived usefulness among users.

- H6. Higher perceived usefulness will result in higher acceptance and adoption of GSP.
- H7. Higher perceived ease of use will result in higher acceptance and adoption of GSP.
- H8. Higher organization support and readiness will result in higher acceptance and adoption of GSP.

To confirm the proposed model, a survey using questionnaire will be adopted for data collection. The unit of analysis for this study are teachers, students and the management of Malaysia's secondary schools. The survey will be conducted on selected schools to obtain information with regard to the usage of GSP in the teaching and learning of Mathematics. The list of schools and permission for conducting the survey will be obtained from the Malaysia's Ministry of Education. Questionnaires will be administered via mail as well as online to 1000 samples (to obtain a minimum of 250 responses for a minimum of 25% response rate). All variables and instruments are constructed using previously validated instruments with minor modifications based on the technology in education context. The result will be discussed in a separate publication write up.

4. Conclusion

The results of this research will be useful in presenting insights on the determinants and inhibitors that would be influencing the acceptance and adoption of GSP as the teaching and learning tools for Mathematics. The success model will be formulated through the adaptation of TAM and TOE constructs is hoped to be instrumental in serving as a guideline for the future planning and implementation of GSP at the national secondary schools which is very in agreement with the goals listed in the Malaysia's Education Blueprint 2013-2015 which is to leverage on the use of ICT to upscale the quality of teaching and learning across Malaysia as well as to equip future graduates with the 21st century skills.

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6. References

i. Ramli, R., & Ramli, R. (2013). ICT Supported Cooperative Learning-Towards Attaining 21st Century Skills. International Journal of Asian Social Science, 3(9), 2026-2033.
ii. Official Website of Economic Planning Unit. Retrieved from the 11th Malaysia National Plan. Retrieved from http://www.epu.gov.my/en/rmk/eleventh-malaysia-plan-2016-2020
iii. Trilling, B. and Fadel, C. 2009. Partnership for 21st century skills. 21st century skills: learning for life in our times.
iv. Cloud, J. 2010. 21st century skills. Technology, (2010).
v. Rotherham, A. J. and Willingham, D. T. 2010. 21st-century skills. American Educator, 17.
vi. The Star Online (2016) Pact to prepare students for 21st century learning. Retrieved https://www.thestar.com.my/news/education/2016/11/27/pact-to-prepare-students-for-21st-century-learning/
vii. Malaysia Ministry of Education (2012) Preliminary Report - Malaysia's Education Blueprint 2013-2025.
viii. The Malay Mail Online (2018) 21st century learning method for full implementation in March Retreived from http://www.themalaymailonline.com/malaysia/article/21st-century-learning-method-for-full-implementation-in-march
ix. Eu, L. K. (2013). Impact of Geometer's Sketchpad on students achievement in graph functions. The Malaysian Online Journal of Educational Technology, 19.
x. Meng, C.C and Sam, L.C. (2011). Encouraging the Innovative Use of Geometer's Sketchpad through Lesson Study. Creative Education, 2, 236.
xi. Garofalo, J., & Bell, R. L. (2004). Technology Reviews: A New Look at Geometer's Sketchpad: Teaching Area Across Grade Levels. School Science and Mathematics, 104, 233-239.Chapman, K. R., & Arunatileka, S. M. (2010, July). Teleconsultation roadmap—the path to telemedicine. In e-Health Networking Applications and Services (Healthcom), 2010 12th IEEE International Conference on (pp. 74-80). IEEE
xii. McClintock, E., Jiang, Z., & July, R. (2002). Students' development of 3D visualization in the Geometer's Sketchpad Environment
xiii. Almeqdadi, F. (2000). The Effect of Using the Geometer's Sketchpad (GSP) on Jordanian Students' Understanding of Geometrical Concepts
xiv. Teoh Boon Tat & Fong Soon Fook. (2005). The effects of Geometer's Sketchpad and Graphic Calculator in the Malaysian Mathematics classroom. Malaysian Online Journal of Instructional Technology 2(2): 82-96.
xv. Ramli, R., Ramli, R & Mustapha, R. (2014). A study on the effectiveness of a technology supported approach in the teaching of mathematics—Using Geometers' Sketchpad (GSP). Proceedings of Technology, Informatics, Management, Engineering, and Environment (TIME-E), 2014 2nd International Conference on (pp. 105-110)
xvi. Ismail, S. A., Dorner, D., & Oliver, G. (2011). Issues Related To Information Literacy Education in Malaysian Schools.International Proceedings of Economics Development & Research,
xvii. Bismillah Khatoon Abdul Kader (2008). Malaysia's experience in training teachers to use ICT. In E. Meleisea (Ed.), ICT in teacher education: Case studies from the Asia-Pacific region (pp. 61-66). Bangkok: UNESCO

xviii. Mustapha, R. & Ramli, R (2014). An Investigation on the GSP Implementation in the Teaching of Mathematics at a Malaysian Technical School. Journal of Asian Vocational Education and Training, 7, 74-83
xix. Levpušček, M.P and Zupančič, M. (2009). "Math Achievement in Early Adolescence: The Role of Parental Involvement, Teachers' Behavior, and Students' Motivational Beliefs About Math." The Journal of Early Adolescence 29, no. 4: 541-570.
xx. Humphrey, M. and Hourcade, J. 2010. Special educators and mathematics phobia: An initial qualitative investigation. The clearing house: A Journal of Educational Strategies, Issues and Ideas, 83(1): 26-30.
xxi. De Wet, P. 2010. What skills must a grade 7 have to succeed with high school maths? Learning and Teaching Mathematics, 8(2010): 36-40
xxii. DeAbreu, R. J. 2012. Twisting, stretching, and bending: A Case for Flexibility in Today's Model of Mathematics Education.
xxiii. Abdullah, A. H., Surif, J., Ibrahim, N. H., Ali, M., & Hamzah, M. H. (2014). The Development of MyGSP: An Online Resource for Teaching Mathematics Based on Geometer's Sketchpad (GSP). Asian Social Science, 10(22), p227.
xxiv. Warabhorn, P., Devadason, R. P., Wahyudi, Cheah, U. H., & Teoh, B. T. 2012). Teachers' Use of the Geometer's Sketchpad in Malaysian Secondary Schools: A Survey Report. Malaysia: Penang. SEAMEO RECSAM.
xxv. Saxena, M. K., Bala, R., & Upadhyay, M. (2014). A Study of Computer Phobia among Prospective Teachers. Learning Community-An International Journal of Educational and Social Development, 5(2and3), 129-136.
xxvi. Shinde, M. P. V., & Shinde, M. V. D. (2014). Analytical Study of Smart Teaching Techniques. Vol. No. 2 Issue No. 2 August 2014, 107.
xxvii. Oliveira, T., & Martins, M. F. (2011). Literature review of information technology adoption models at firm level. The Electronic Journal Information Systems Evaluation, 14(1), 110-121.
xxviii. Pai, F. Y., & Huang, K. I. (2011). Applying the Technology Acceptance Model to the introduction of healthcare information systems. Technological Forecasting and Social Change, 78(4), 650-660
xxix. Stols, G., & Kriek, J. (2011). The understanding of teachers' use of the Geometer's Sketchpad in their classrooms.
xxx. Gu, X., Zhu, Y., & Guo, X. (2013). Meeting the" Digital Natives": Understanding the Acceptance of Technology in Classrooms Educational Technology & Society, 16(1), 392-402
xxxi. Fluck, A., & Dowden, T. (2013). On the cusp of change: examining pre-service teachers' beliefs about ICT and envisioning the digital classroom of the future. Journal of Computer Assisted Learning, 29(1), 43-52.
xxxii. Tornatzky, L. G., Fleischer, M., & Chakrabarti, A. K. (1990). Processes of technological innovation. Lexington Books.
xxxiii. Bhati, A., Toe, T. T., Lundberg, A., & Carter, M. (2014). Wireless Learning Technology in Higher Education–a Case Study in Singapore. Journal on Computing (JoC), 3(3).
xxxiv. Muda, M. N., & Yusof, Z. M. (2015). Conceptual Framework for Knowledge Sharing Initiative in Institution of Higher Learning to Enchance The Teaching Performance and Innovation. Scientific Journal of PPI-UKM, 2(1), 10-16.