

Effects of Interactivity on Students' Intention to Use Simulation-Based Learning Tool in Computer Networking Education

Hsin-ke Lu *, Peng-chun Lin *

** School of Continue Education, Chinese Culture University, Taiwan (R.O.C.)*

sklu@sce.pccu.edu.tw, pclin@sce.pccu.edu.tw

Abstract— With the proliferation of information and communication technology, computer network has been an integral part of our modern world. Nowadays, computer networking concepts have been an essential knowledge in computer and information technology education. However, computer networking concepts are quite abstract and complex. To improve students' understanding, simulation-based learning (SBL) tools were introduced. While previous study focused on examining the design pattern of SBL tools, few have investigated students' perception toward the SBL tools. To advance the understanding of the simulation-based learning process, this study adopted Packet Tracker (PT), a SBL tool introduced by Cisco Inc., in the course - "Introductory Course of Information Technology" of a university in northern Taiwan. A research framework was proposed to discuss relationship between system interactivity, perception toward PT, learning outcome and intention. Research results show the interactivity of SBL tools could be a key feature that developers need to be considered when developing. Moreover, students' perceptions of usefulness and educational value have divergent effects on self-evaluation and intention to use. Lastly, students' intrinsic motivation is important, design better instructional methods that could foster students' intrinsic motivation is still of great importance.

Keywords— Simulation-Based Learning, Computer Networking, Packet Tracer, Computer-Assisted Learning, Interactivity

I. INTRODUCTION

Along with the advances of Information and communication technology, computer network has been an integral part of our modern world. The courses that introduce information technology have integrated networking concepts as a fundamental component in higher education. Moreover, these courses also seek to advance students' understanding by incorporating practice. However, due to the limited resources, computer hardware cannot be available for every student. To address this issue, simulation-based learning tools were introduced.

Plenty of networking simulation tools had been developed by different companies. Packet Tracer (PT) which developed by Cisco System have been a well adopted simulation-based learning tool in academies around the world. According to

Frezzo et al. [6], incorporating PT into instruction provides structured, guided, and simulated real situations learning activities for students. Moreover, PT also visualizes the dynamic process of computer networking. For example, PT visualizes the process that packets transmitted through network devices and shows information encapsulated in packets. It is an essential concept for network learning and nearly impossible to be directly observed in real word. PT also provides graphical user interface and prompt response to the user's action. Using Packet Tracer to learn networking concepts, students can be easier to gain a more comprehensive view of computer networks. In comparison with animated learning materials, PT provides flexibility for instructors to depict the complex and abstract concepts.

While many studies have explored the effectiveness of simulation-based learning (e.g. [1]-[3]), little of them have investigated using SBL in assisting computer networking learning. On the other hand, few studies addressed the functionalities and effectiveness of PT recently (e.g. [4],[5]). However, most of this study did not make inquiries about students' perception toward the SBL tool and its relationship with students' learning outcome and usage intention. To fill up this literature gap, this study seeks to incorporate innovation adoption literature to address the relationship mentioned above.

For an SBL tool, one important feature that can affect user's system perception is interactivity [6]. Learning is an interactive process. Through the interaction, student could develop a clearer and more complete understanding. In this manner, the quality of interactivity that students perceived could affect their overall impression which further influences their usage intention. Thus, this study is to investigate whether interactivity influence students' perception of SBL tool, i.e. packet tracer.

Previous technology acceptance literature suggested that users' perception of a system, such as usefulness, enjoyment etc., would affect both their usage intention and perceptions of benefits of the system delivered. In the learning context, the benefits could be referred to the students' advances of understanding of the specific subject. The subjective judgment of learning outcome could be measured by students' self-evaluation. Adapted from related studies, this study

proposes usefulness, education value, and enjoyment to capture the positive perception of the PT (e.g. [7],[8]).

In specific, the purposes of this study are as follows:

1. To investigate the relationship between the interactivity and students' positive perceptions of Packet Tracer.
2. To explore the relationship between students' positive perceptions of Packet Tracer with their self-evaluation of learning outcome.
3. To explore the relationship between students' perception of Packet tracer and self-evaluation and future usage intention.

II. RESEARCH METHOD

According to the research questions of this study, researcher proposed the research framework as shown in Figure 1, and the research hypotheses are proposed as follows:

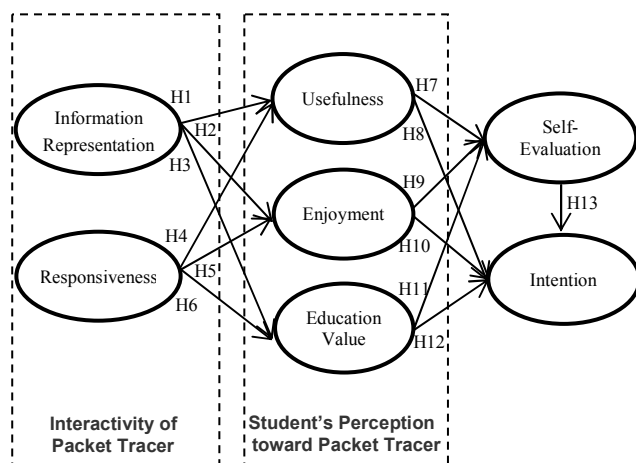


Figure 1: Research Framework

- H1: The information representation of PT is positively associated with perceived usefulness of PT.
H2: The information representation of PT is positively associated with perceived enjoyment of PT.
H3: The information representation of PT is positively associated with educational value of PT.
H4: The responsiveness of PT is positively associated with perceived usefulness of PT.
H5: The responsiveness of PT is positively associated with perceived enjoyment of PT.
H6: The responsiveness of PT is positively associated with perceived educational value of PT.
H7: The perceived usefulness of PT is positively associated with self-evaluation of PT.
H8: The perceived usefulness of PT is positively associated with intention of PT.
H9: The perceived enjoyment of PT is positively associated with self-evaluation of PT.
H10: The perceived enjoyment of PT is positively associated with intention of PT.
H11: The perceived educational value of PT is positively associated with self-evaluation of PT.

H12: The perceived educational value of PT is positively associated with intention of PT.

H13: The self-evaluation of PT is positively associated with intention of PT.

This survey was conducted in a university of northern Taiwan. The participants are 43 students who attend the course - "Introductory Course of Information Technology". The chapter that introduces computer networking was used for data collection in this study. Specifically, each topic of computer networking was firstly lectured by instructor followed by a Packet Tracer simulation session or task as practical exercises.

The questionnaire used in this study is comprised of four major parts. Measurements were primarily adapted from previously validated instruments. The first part collects the demographic information of participants, such as gender, age, computer and Internet experience.

Second part collects students' perceived system interactivity. The Interactivity of PT can be divided into two components; the first one is information representation which refers to the extent of understand ability of PT's visual presentation. It measures students' perception of whether PT's interface can denote clear and understandable information. Second, responsiveness refers to how fast user can get feedback from system when they changed devices setting in PT. 4 items were used to measure information representation and 3 items for responsiveness [9].

The third part gathers students' perceptions toward to PT. A total of 15 items were adapted from Wrzesien and Alcaniz Raya's work [8] to measure PT's appeal to student. The perceived usefulness in this study refers to the students' perception of PT that if it could facilitate better learning. The perceived enjoyment refers to the extent of joy when interacting with PT in learning. The next is perceived educational value which focuses on students' perceptions toward if PT can help them to gain a more comprehensive knowledge and operational skills of computer networking. And the last one is intention to participate which refers to the extent of students' willingness to use PT in learning computer networking concepts in the future.

The last part, participants were asked by 9 items to self-evaluate his/her learning outcome. Self-evaluation can stand for the perception of benefits that students may derived after using PT. Sample item such as "I can complete the assigned task without seeking other's help" was presented in this section.

III. DATA ANALYSIS AND RESULT

Among the 43 valid responses, 56% (or 24) were female. Most of the respondents were in age under 20 (42%), followed by those who are of age between 21-25 (33%). For previously learning experience, most of the respondents (86%) are not information technology related major in their Senior High or Vocational School. Meanwhile, around 65% of the respondents have more than ten years of computer experience.

Data were analysed using Partial Least Square (PLS) approach. PLS is a structure equation modelling approach which is known for its ability to handle complex relationship among variables and resampling techniques in dealing with small sample size (e.g. [10],[11]). For the small sample size and exploratory nature of this study, PLS is considered as an appropriate approach for this study. The SmartPLS 2.0 M3 was used in this study for data analysis [12].

Path coefficients were assessed using bootstrapping technique. As shown in Figure 2, all path coefficients were significant at $p < 0.05$ except H4, H9 and H12. Both the Information Representation and responsiveness are positively associated with perceived enjoyment ($\beta = 0.39$, $\beta = 0.33$, $R^2 = 0.480$) and perceived educational value ($\beta = 0.59$, $\beta = 0.26$, $R^2 = 0.674$). However, only information representation is positively associated with perceived usefulness ($\beta = 0.81$, $R^2 = 0.731$). Moreover, usefulness is positively associated with Self-Evaluation ($\beta = 0.39$, $R^2 = 0.492$) and intention ($\beta = 0.55$, $R^2 = 0.785$). Perceived enjoyment is positively associated with intention ($\beta = 0.28$, $R^2 = 0.785$). Perceived education value is positively associated with self-evaluation ($\beta = 0.27$, $R^2 = 0.492$). Finally, self-evaluation is positively associated with intention ($\beta = 0.17$, $R^2 = 0.785$). Implications for these results are to be presented in the following section.

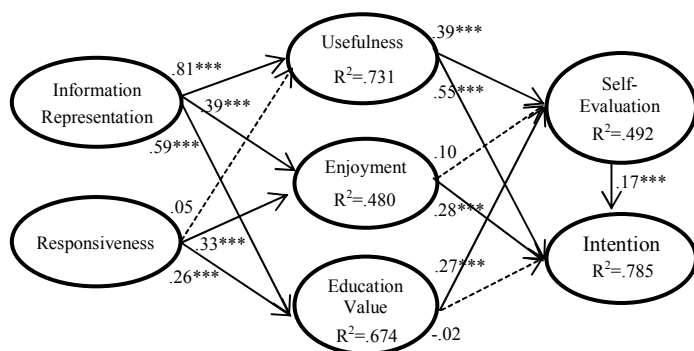


Figure 2: Results of PLS
***: $p < 0.001$

IV. DISCUSSION AND CONCLUSION

This study adopted Packet Tracker (PT), a simulation-based learning tool, in the course - "Introductory Course of Information Technology" of a university in northern Taiwan. This study proposed a research framework that incorporates interactivity of PT, students' perceptions toward PT, self-evaluation and intention as research variable. A Survey was used to collect data and PLS was used to analyse the data collected. Interpretations of research results are presented as follows.

For the Interactivity of PT, results show that interactivity of PT, both information representation and responsiveness, is significantly associated with perceived enjoyment. This finding could be attributed to that simulation tool's graphical interactive interface and real-time responsiveness which make

students feel like they were playing computer games during the learning process. Furthermore, perceived enjoyment is significantly associated with intention. One possible reason would be that if students feel pleasure in using PT to learn, they might form higher intention to use it in the future. In addition, information representation is positively associated with perceived educational value. This could be attributed to the features of PT for it can visualize the complex and dynamic process of computer networking. The computer networking concepts and interaction among devices could be quite abstract and dynamic for it cannot be directly observed in real world. Through PT's visualization features, student could improve their understanding of computer networking concepts more effectively.

For students' perception toward PT, most of the hypotheses proposed by this study were supported. These finding is consistent with previous technology acceptance related literature (e.g. [13]-[15]). However, few of the hypotheses failed to be supported in this study.

First, H4: Responsiveness to usefulness is not supported. One plausible explanation would that most students do not have prior knowledge of computer networking. Therefore, students might not be able to understand the meanings of system's feedback in the timely manner when specific changes were made. Thus, instructors may depict the networking concepts through lecturing which helps students gain some pre-requisite knowledge or related concepts before they engaged with SBL tool. Second, test of H9: enjoyment to self-evaluation is not significant. The reason might be that even if students sense the joy as they were using PT to learn. However, the learning session is rather short which might be the limitation for student to build better learning outcome. Lastly, H12: Educational value to Intention is not significant. Educational value refers to students' perception of the value that PT can deliver in assisting learning computer networking. The insignificant result could be due to that students may not have interest (intrinsic motivation) in learning computer networking. Thus, even students perceived that PT is of great educational value in learning computer networking, they might still not intent to use PT in the future for lacking of interest in learning the subject.

Implications for research findings are as what followed. First, for developers of simulation-based learning tool, interactivity, both information representation and responsiveness are influential factors in affecting students' perceptions toward PT. In this manner, interactivity could be a key feature that developers need to be considered in developing SBL tool. Second, students' perceptions of usefulness and educational value have divergent effect on self-evaluation and intention to use. These findings signify the importance of intrinsic motivation in students' effective learning. Thus, by introducing novel technology in learning might not automatically facilitate effective learning. Designing better instructional methods that could foster students' intrinsic motivation is still of great importance.

V. RESEARCH LIMITATION AND FUTURE RESEARCH

The sample size would be a primary limitation for this study. Through the resampling technique of PLS, this small sample size issue could be basically addressed. However, future research is suggested to conduct research with larger sample size to increase the generalizability of research results. The second limitation for this study is the duration of students' using PT. Participants in this study was constituted of students in introduction course of information technology. To improve their understanding of networking concepts, this study employed PT to assist students' learning when introducing computer networking. In other words, students may not spend time long enough to form a stable perception. Future research is encouraged to use longitudinal research design. During the learning process, researchers can simultaneously observe students' behavior of interacting with SBL tool. Thus, students' cognitive presence when using SBL tool can be closely scrutinized. Lastly, interactivity is one facet of system characteristics of SBL. Future research could incorporate more system characteristic variables into the research framework and examine its relationship with students' perception and learning outcome.

REFERENCE

- [1] Chung, G. K. W. K., Harmon, T. C., & Baker, E. L. (2001). The Impact of A Simulation-Based Learning Design Project On Student Learning. *Education, IEEE Transactions on*, 44(4), 390-398.
- [2] de Freitas, S., & Oliver, M. (2006). How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? *Computers & Education*, 46(3), 249-264.
- [3] Yehzekel, C., Eliahu, M., & Ronen, M. (2009). Easy CPU: Simulation-based Learning of Computer Architecture at the Introductory Level. *International Journal of Engineering Education*, 25(2), 228-238.
- [4] Frezzo, D., Behrens, J., & Mislevy, R. (2010). Design Patterns for Learning and Assessment: Facilitating the Introduction of a Complex Simulation-Based Learning Environment into a Community of Instructors. *Journal of Science Education and Technology*, 19(2), 105-114.
- [5] Frezzo, D. C., Behrens, J. T., Mislevy, R. J., West, P., & DiCerbo, K. E. (2009). *Psychometric and Evidentiary Approaches to Simulation Assessment in Packet Tracer Software*. Paper presented at the 2009 Fifth International Conference on Networking and Services, Valencia, Spain.
- [6] Dalgarno, B., & Lee, M. J. W. (2010). What are the learning affordances of 3-D virtual environments? [Article]. *British Journal of Educational Technology*, 41(1), 10-32.
- [7] Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. [Article]. *MIS Quarterly*, 27(3), 425-478.
- [8] Wrzesien, M., & Alcañiz Raya, M. (2010). Learning in serious virtual worlds: Evaluation of learning effectiveness and appeal to students in the E-Junior project. *Computers & Education*, 55(1), 178-187. doi: 10.1016/j.compedu.2010.01.003
- [9] Johnson, G. J., Bruner Ii, G. C., & Kumar, A. (2006). Interactivity and Its Facets Revisited. [Article]. *Journal of Advertising*, 35(4), 35-52.
- [10] Chin, W. W. (1998). Issues and opiiion on structural equation modeling. *MIS Quarterly*, 22(1), vii-xvi.
- [11] Haenlein, M., & Kaplan, A. M. (2004). A Beginner's Guide to Partial Least Squares Analysis
- [12] Ringle, C. M., Wende, S., & Will, A. (2005). SmartPLS, from <http://www.smartpls.de>
- [13] Lau, S.-H., & Woods, P. C. (2009). Understanding learner acceptance of learning objects: The roles of learning object characteristics and individual differences. *British Journal of Educational Technology*, 40(6), 1059-1075.
- [14] Sánchez, R. A., & Hueros, A. D. (2010). Motivational factors that influence the acceptance of Moodle using TAM. *Computers in Human Behavior*, 26(6), 1632-1640.
- [15] Yuen, A. H. K., & Ma, W. W. K. (2008). Exploring Teacher Acceptance of E-learning Technology. *Asia-Pacific Journal of Teacher Education*, 36(3), 229 - 243.