4th World Congress on Technical and Vocational Education and Training (WoCTVET), 5th–6th November 2014, Malaysia

Vickers Test Simulation to Improve Metacognitive Skills

Ahmed Hadi Shubber[a, b,*], Amirmudin Bin Udin[a], Asnul Bin Minghat[a]

[a]Universiti Tecknologi Malaysia, Skudai 81310. Johor Bahru (MALAYSIA)
[b]Foundation of Technical Education Iraq

Abstract

Improving the metacognitive skills via celebrated Vickers Test Simulation (VTS) is an outstanding issue in science and engineering education. The quest for achieving accurate model in designing educational curricula and methods for solving engineering problems metacognitively is ever-growing. Enhancing the problem solving efficiency through planning, analyses, design and implementation mediated by metacognition is a challenging task. We designed, developed and evaluated engineering simulation using VTS to identify the effectiveness of metacognitive skills on mechanical engineering students (metallurgy) of Iraq as test sample. The influences of VTS on metacognitive acquisition skills through self-planning, self-monitoring, self-modification and self-evaluation are determined. The performance of the proposed model is simulated via Microsoft studio 2010 and the data are analyzed by SPSS. The validity and reliability of the test questions are determined from the values of Answer time, Coefficients of Reliability, Discrimination, Difficulty and Correlation. The calculated value of T is found to be 7.822 for self-planning, 7.864 for self-monitoring with significance ~0.01. Results reveal that VTS has considerable impact on metacognitive skills acquisition.Our systematic methodmay constitute a basis for students and learners in solving analytical and technical problems in a competent manner to enhance their metacognitive skills.

Keywords: VTS,simulation, metacognitive skills, acquisition, metallurgy.

_____

* Corresponding author. Tel.: +601119159150.

    *E-mail address:*ahmed.shuber@gmail.com

1. Introduction

Lately, simulation-based training is emerged as one of the most popular modes of instruction for teaching complex tasks. These systems are not only more cost-effective but allow the training to occur in a safeand realistic fashion. However, the effectiveness of such systems remainunclear as far as training outcomes is concerned(Bell et al., 2008; Salas & Cannon-Bowers, 2001).Much of the current research on the effectiveness of simulation-based trainingprimarily focuses on the systems as a whole, rather than the specific individual features(Cannon-Bowers & Bowers, 2009). Thus, simulation-based training development efforts must identify effective guidance and support strategies to optimize training outcomes(Cannon-Bowers & Bowers, 2009; Bell et al., 2008; Bell & Kozlowski, 2007). Our interest is to explore thoseinnovative approaches in which computer simulation can enhance quality of education by covering other learning phases and helps students to acquire metacognitive as well as domain independent learning skills.

Metacognitive skills development assistsstudents to be self-regulated learners(Eggen & Kauchak, 1996), where they acquire a responsibility upon their own learning progress and adopt learning strategies to pursue the demand of duty. Metacognitive skill playsapivotal role on several cognitive activities including comprehension, communication, attention, memory and problem solving(Howard, 2004).Several researchers believe that the ineffective implementation of various strategies can cause learning failure. Truly, this skill plays a critical role towards successful learning (Livingston, 1997). Veenman emphasized the inevitable acquirement of metacognitive skills and its practical relevance in problem solving scenario.His approach allows students to acquire and access metacognitive skills in a computerized environment(Veenman, 2013). Pennequin et.al asserted that, metacognition is prerequisite in articulation, understanding, reading, writing, knowledge acquisition, retention and rational judgment. It is also affirmed that, the proficiency level of a population's problem solving skills is majorly determined by the systematic home and school training where the increased number and quality of children's metacognitive knowledge and monitoring skills play paramount role(Pennequin et al., 2010). We aim to identify the characteristics of simulation design fulfilling the requirement of engineering learning, design, develop and evaluate the VTS, and determine the influences of VTS on metacognitive skills.

2. Theoretical Background

The lack of analytical skills and problem-solving inability of Iraqi technical institutes students are acknowledged by the Ministry of Higher Education and Science of Iraq in the National Development Plan of 2010-2014 and United Nations Human Settlements.The scarcity of modern laboratories and the exploitation of traditional methods are found to be the reason for such deficiencies(Ministry of Higher Education & Scientific of Iraq, 2012; Ministry of Planning Republic of Iraq, 2010; United Nations Human Settlements -UNHABITAT, 2009). According to Al-Mosawi, metallurgy is one of the hardest lessonstaught to mechanical engineering students where many of them often fail in the first attempt and the successrate over the last five years is the lowest (20%). Teacher's delivery significantly impacts student's information absorption because most theoriesare difficult and the learning lessons are not directly linked to the examination(Al-Mosawi, 2013). In the present research, three mainaspects of such failure are explored in the context of Mechanical Department students in Technical Institutes of Iraq. Firstly, learner'sinability to apply the knowledge of metallurgy in spite of their sufficient theoretical background is recognized.Secondly, their difficulties in understanding the functions of machines in metallurgylaboratory are identified.Finally, the reasons for the lack ofpractical and technical problems solving skills of these graduates are determined.

The investigation majorly focused, (a)to address the challenges associated in acquiring and using information and knowledge,(b) to concentrate on problems related to the modalities or methods of searching and using VTS in problem solving scenarios and (c) to tackle the difficulties connected with incompetent implementation of analytical ideas during problem analysis and comprehension.

3. Study question

What is the impact of VTS on metacognitive skills (self-planning and self-monitoring)?

4. Scope of the study

1. The study is subjected to second-grade students of Mechanical Department in Babylon Technical Institute of Iraq in the academic year 2014.
2. The research is limited to their metacognitive skills development for metallurgy's laboratory lesson.
3. The lectures are only confined to the computer laboratory.

5. Methodology

5.1. Study Design and VTS Development

A pretest-posttest experimental design is used on total 75male students in the age groupof 20 to 24 years. They are divided into two groups in which the experimental one consists of 38 students and 37are in the control group. These students are deliberately chosen for the case study due to their suffering and failure in learning the subject. The experiment is conducted for 6 hours in two weeks duration,where all students began their lessons at 9:30 am on Monday (control group) and Wednesday (experimental group). Lack of potential in solving problems inside or outside the laboratory is found to be related with their traditional methods based limited knowledge. Students with age anomalies and who failed in the previous years in equivalent lessons are excluded from participation.

Before starting the experiment, the methods of pilot survey are used to enhance the reliability and validity of the study instrument. Also after that, the method of T-test is used to assess the impact of simulation in the development of metacognitive skills.

5.2.VTS Objectives

The identification of goals for the construction of lesson is considered as the important standard to determine their contents, nature, activities and exercises accompanying the methods. Furthermore, themodes of using particular teaching methods and the goals for lessons are categorized into general and special one.General goal primarily focuses to develop the metacognitive skills including self-planning and self-monitoring in the metallurgy lesson.Conversely, the aims ofspecial goals areto administer students to the following objectives:

1. To identify when, where and how to use Vickers Hardness Test (VHT).
2. To identify the parts and components of VHT.
3. To identify sequence of steps involved for VHT.
4. To identify advantages and disadvantages of VHT.
5. To aware of safety measures for machines usage.
6. To measure Vickers Hardness correctly.

5.2. Preparation of Simulation

The simulation process is developed and evaluated for VTS models in the metallurgy lesson as described hereunder.

5.2.1. Simulation Development Process

The development processes of VTS are illustrated in Fig. 1 (Heath et al., 2009; Scheinman, 2009). The computer language Microsoft Studio 2010 is used to design and develop the VTS model. A performance evaluation of the proposed model is carried out to identify their strengths and weaknesses through pilot test. A group of experts with mechanical engineering background with their method of teaching are chosen to conduct such tests. VTS development involves the underlined steps:
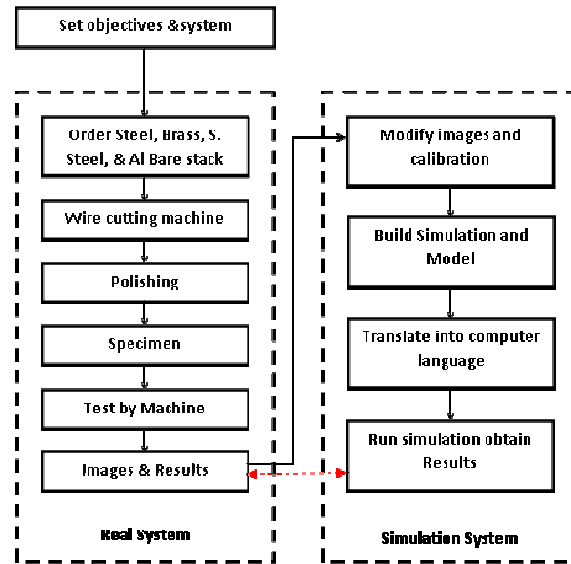

Fig. 1.   Block diagram for the simulation development processes.

1. Identification of general and special goal of the model.
2. Use of metals group such as stainless steel, mild steel, steel, brass and aluminum in conducting the real test.
3. Manufacturing specimens from these metals by machines turning and milling, wire cutting and polishing suitable for the apparatus specified in the research.
4. Conducting the test on real apparatus. In addition to the registration of the real data and results during the test, capturing pictures of each step, movement and reading of apparatus are also considered.
5. Modification and calibration of pictures for the measurements are performed with the real equipment and specimen using a set of computer programs such as Photoshop and other image processors.
6. Designing a computer program using Microsoft Studio 2010 to simulate the model and conversion of data and images to the software codes. Devising the computer interfaces representing the real test steps.
7. Acquiring data from the program alike a real machine when running the simulation or executing the program.

The user is responsible for checking the statement true or false with the possibility of re-trying it several times, data collection and storage in specific places to beaudited.

5.2.2. Simulation Design

VTS design is performed using the following stages:
A.   Design of Screen1 as depicted in Fig. 2-ais comprised of the following options:
   1. ABOUT VICKERS TEST: Review the information related to Vickers test.
   2. ABOUT SIMULATION: Review the information relating how to use the simulation?
   3. TEST STEPS: Review the information related to the test step.
   4. SIMULATION TEST: Move to the next screen to use simulation for Vickers test.

    5. EXIT: End of program.

B. Design of Screen2 as shown in Fig. 2-b includes the following options:
    1. Aluminum Al: Use Aluminum specimen and next screen.
    2. Steel: Use Steel specimen and move to the next screen.
    3. Brass: Use Brass specimen and move to the next screen.
    4. S-Steel: Use S-Steel specimen and move to the next screen.
    5. EXIT: End of program.
    6. Back: Back to the previous screen.

C. Design of Screen3 as illustrated in Fig. 2-c contains the following choices:
    1. Keys (1, 5, 10, 20, 30, 50): To choose load (Kgf) 1 or 5 or …etc.
    2. RESET: Reset and clear all data before start test.
    3. Image: To explain the Vickers test machine.
    4. On image table elevating handle for up or down by Click.
    5. On image start key: To start load apply button and begin test.
    6. Timer: Explain test time (15s).
    7. SHOW AND MEASURE SAMPLE: Move to the next screen to watch and measure the specimen under a microscope.
    8. EXIT: End of program.
    9. Back: Back to the previous screen.

D. Design of Screen4 as displayed in Fig. 2-d encloses the following options:
    1. Image: To explain specimen under a microscope.
    2. On image one can draw lines to the length of the diagonals (d1& d2) by drag-and-drop mouse.
    3. A set of labels give length of the diagonals mm (d1), length of the diagonals mm (d2), average length of the diagonals (mm) and square length of the diagonals (mm^2) during to diagonal measurement.
    4. Clear All: Delete all data and start again.
    5. Information Text: Contains Vickers test equation.
    6. Input Text1: To Input the load value (P).
    7. Input Text2: To Input square length of diagonals.
    8. Key (=): To show the value of Vickers Hardness.
    9. VHN Text: Contains Vickers Hardness value.
    10. Label: To check whether the result is true or false.
    11. EXIT: End of program.
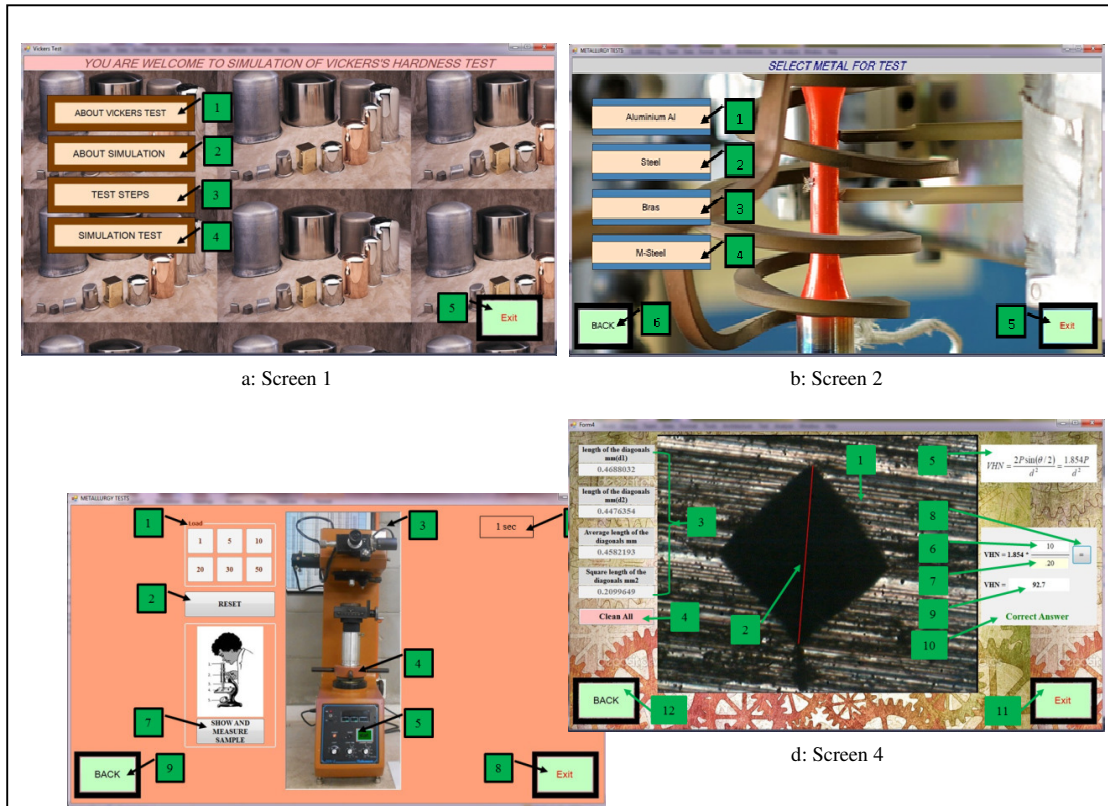   12. Back: Back to the previous screen.

Fig. 2.   (a-d) Schematic diagram displaying the design of screens for simulating Vickers test machine.

5.2.3. Assessment Methods

In the end of any academic or intellectual exercise, students are subjected to various examinations to determine the level of their understanding about the subject matter. These evaluations or feedbacks acting as indicator often reveal the extent at which the goals specified for each lesson are achieved. The first category of assessment determines the level of acquired knowledge in terms of the general and specific goals of the lesson. The second kindverifies the validity of various techniques such as test, examination, quizzes, assignments, group and individual project. Meanwhile, the final category deals with the control of the consistency of the acquired knowledge with proof of utilization in a problem solving exercise. We used multiple choices to evaluate the following:
1. The simulation that is designed for the suggested apparatus (VTS).
2. The test questions of the pretest and post-test.

5.2.3.1. Content validity-to confirm and get consensus from experts

This approach is employed to evaluate the simulation design which in turn increases the reliability and validity of the study instrument in identifying the presence of possible deficiencies during actual implementation(Hair et al., 2006; Cooper & Schindler, 2000). Furthermore, interview responses from six specialists in mechanics are combined to modify the formulation of paragraphs, number and contents fitting the general and specific objectives of the study. The scientific accuracy, linguistic, coverage of the vocabulary curriculum and the suitability of simulation for

mechanical engineering students is meticulously considered. The opinions and views of specialists are considered in modifying, deleting and adding some paragraphs to VTS.

5.2.3.2. Instrument of Study

Following Shen, Erskine and Gama (Shen & Liu, 2011; Erskine, 2009; Gama, 2004),total 20 questions are prepared to evaluate two metacognitive skills. The test questions on experimental sample comprised of 32 students are applied to ensure the test validity and reliability. The real time of test, Internal Consistency Validity, Discrimination Coefficient, Difficulty Coefficient and Test Reliability are determined as listed in Table 1. The confidence of the validity and reliability of the test questions are clearly evidenced.

Table 1. Result of validity and reliability before real test.

validity and reliability items	Value or range	Mean
Answer Time	20 min	20 min
Discrimination Coefficient	0.556 - 0.778	0.667
Difficulty Coefficient	0.25 - 0.6875	0.4688
Internal Consistency Validity (Pearson)	0.478 - 0.646	-
Reliability Coefficient (Kuder- Richardson)	0.868	-

6. Results and Discussion

A quantitative approach is used to examine the impacts of VTS on metacognitive skills.The post-test andthe hypotheses used to address the research questions are related to the effects and measure of VTS in developing metacognitive skills (self-planning and self-monitoring). They are defined as,

(i) H0 = No statistically significant differences in the (self-planning and self-monitoring) skills at 0.05 level of significance between the control and experimental group on post-test.

(ii) H1 = Statistically significant differences in the (self-planning and self-monitoring) skills at 0.05 level of significance between the control and experimental group on post-test.

Table 2. Independent samples test for metacognitive skills.

	Groups	N	Mean	T	Sig. (2-taile)
Self-planning	Experimental group	38	38.90	7.822	0.000
	Control group	37	27.59		
Self-monitoring	Experimental group	38	39.18	7.864	0.000
	Control group	37	27.56		

Table 2 clearly reveals that the calculated value of "T" is greater than the critical value from "T Table" for self-planning and self-evaluation skills in post-test (function is at the level of significance 0.01). This indicates the presence of statistically significant differences between experimental group and the control group which allows one to reject the null hypothesis (H0) and accept the alternative hypothesis (H1). The achieved differences are found to be in favor of the experimental group.

7. Conclusions

The impacts of VTS inattaining metacognitive skills through self-planning and self-monitoring are reported. The effectiveness of metacognitive skills is identified and determined via VTS for mechanical engineering students in metallurgy lesson of Iraq technical institute as test sample. VTS is found to enhance student's problem solving efficiency and enable in achieving metacognitive skills. The performance of the developed model is observed to be quite robust. The validity and reliability of the test questions are determined usingdifferent coefficients such asreliability, discrimination, difficulty and correlation.Simulation results exhibit that the T values for self-planning and self-monitoring skills for post-test are greater than the value of T-table. Our hypotheses supported by the data indicate that students are capable of understanding metallurgy texts more effectively after the introduction of metacognitive skills acquisition process. It is established that the simulation and metacognition skills are fundamental tools that enable learners to take control of their own cognition, emotion and motivation. VTS approach allows students to solve ill-structured problems in any academic environment, particularly in engineering education. Furthermore, students depending on themselves in learning, problem-solving and awareness may use simulation to acquirehigh level of understanding and become productive learner. Simulation strongly influences the metacognitive skills andresults an increase in the susceptibility of students overall academic achievements. It is demonstrated that VTS can constitute a basis for learners promising capabilities. The notable improvement in metacognitive skills mediated via VTS implies that the institutions of higher learning may take initiative in introducing metacognition as a compulsory course for students across all disciplines especially in science, engineering, education and medicine. The excellent features of the results suggest that training in metallurgical engineering domain can considerably be enhanced through the introduction of meticulously executed steps including the generation of metacognitive tasks for promoting students reading-comprehension ability. This study may contribute towards the development of practical theories in offering instructive models about conditions leading to the successful process of cognition and learning.

References

Al-Mosawi, A. (2013). Learning Difficulties in Metallurgy Lesson: A Case Study in Technical Institute of Babylon. *Educational Research International*, 2(1), 116–119.

Bell, B. S., Kanar, A. M. & Kozlowski, S. W. J. (2008). Current Issues and Future Directions in Simulation-Based Training in North America. *International Journal of Human Resource Management*, 19, 1416–1434.

Bell, B. S. & Kozlowski, S. W. J. (2007). Advances in Technology-Based Training., in: Werner, S. (Ed.), *Managing Human Resources in North America*. New York: Routledge.

Cannon-Bowers, J. A. & Bowers, C. A. (2009). Synthetic Learning Environments: On Developing a Science of Simulation, Games and Virtual Worlds for Training, in: .Kozlowski, W. J. and Salas, E. (Eds.), *Learning, Training, and Development in Organizations*. Erlbaum: New Jersey.

Cooper, D. R. & Schindler, P. S. (2000). *Business Research Method*. New York: McGraw- Hill.

Eggen, P. D. & Kauchak, D. P. (1996). *Strategies for Teachers: Teaching Content and Thinking Skills*. Boston: Allyn and Bacon.

Erskine, D. L. (2009). Effect of Prompted Reflection and Metacognitive Skill Instruction on University Freshmen's Use of Metacognition. , 1–115.

Gama, C. A. (2004). Integrating Metacognition Instruction in Interactive Learning Environments. *University of Sussex*, 232.

Hair, J. F. J., Black, W. C., Babin, B. J., Anderson, R. E. & Tatham, R. L. (2006). *Multivariate Data Analysis*. Upper Saddle River, NJ: Pearson Prentice Hall.

Heath, B., Hill, R. & Ciarallo, F. (2009). A Survey of Agent-Based Modeling Practices (January 1998 to July 2008). *Journal of Artificial Societies and Social Simulation*, 12(4), 9.

Howard, J. B. (2004). *Metacognitive Inqury*. School of Education: Elon Unive.

Livingston, J. A. (1997). Metacognition: An Overview. Retrieved from http://gse.buffalo.edu/fas/shuell/cep564/metacog.htm

Ministry of Higher Education & Scientific of Iraq. (2012). The Strategic Framework and the General Policies of Technical and Vocational Education in Iraq, in: *Third International Congress on Technical and Vocational Education and Training*, (pp. 2–12). China. Retrieved from www.tvetoman.net/PDF/PDF_AR_7.pdf?

Ministry of Planning Republic of Iraq. (2010). *National Development Plan 2010-2014*. Baghdad. Retrieved from http://www.mop.gov.iq/mop

Pennequin, V., Sorel, O. & Fontaine, R. (2010). Motor Planning between 4 and 7 Years of Age: Changes Linked to Executive Functions. *Brain and cognition*, 74, 107–111.

Salas, E. & Cannon-Bowers, J. A. (2001). The Science of Training: A Decade of Progress. *Annual Review of Psychology*, 52, 471–499.

Scheinman, D. E. (2009). Discrete Event Simulation and Production System Design for Rockwell Hardness Test Blocks. , 41.

Shen, C. & Liu, H. (2011). Metacognitive Skills Development: A Web-Based Approach in Higher Education. *Turkish Online Journal of Educational Technology TOJET*, 10(2), 140–150.

United Nations Human Settlements -UNHABITAT. (2009). *Country Programme Document 2009-2011 :Iraq*. Iraq.

Veenman, M. (2013). Assessing Metacognitive Skills in Computerized Learning Environments, in: Azevedo, R. and Aleven, V. (Eds.), *International Handbook of Metacognition and Learning …*, (pp. 157–168). New York: Springer International Handbooks of Education 26.