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The Impact of Feedback in Computer-Aided Instruction

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Abstract: Computer-Aided Instruction (CAI) can be effectively used in blended learning environment to achieve pedagogical goals. However, CAI systems typically lack of effective feedback mechanisms that ultimately lead to improve learners performance. This study introduces a CAI system equipped with effective dual feedback mechanism. The system provides effective feedback to the learners and maximizes the value of their feedback to instructors. The effect of the system was measured in the field on groups of learners. The results showed that the feedback mechanism of the system has positively impacted the performance of the learners.

Key words: Instructional computing, mathematics, blended learning, adaptive learning environment, feed back, instruction

INTRODUCTION

Introductory mathematics courses for undergraduates offered at universities often times attract a broad range of learners. This background diversity presents challenges to instructors (Mavrikis and Maciocia, 2003). On one hand, effort must be made to provide the learners with common foundation upon which the more advanced topics of the course will be built. On the other hand, if a significant amount of time is spent on foundational (pre-requisite) material the quality of the course will suffer and the more advanced learners will not be sufficiently challenged. The impact of this diversity is greater for Educational Sciences and Arts (EScA) (Fraij, 2008).

Feedback plays a crucial role in learning (Mory, 2004). It was reported in the National Student Satisfaction survey that learners are repeatedly concerned about the lack of feedback (Gill and Greenhow, 2008). Feedback assists learners to restructure their knowledge and support their metacognitive process (Clark and Dwyer, 1998; Foote, 1999; Warden, 2000). To provide information to a learner, there are three generic feedback approaches: knowledge of response which provides the learner with correct or incorrect response; knowledge of correct response which informs the learner about the correct answer and elaborated feedback which provides the learner with explanation about why his or her response was correct or incorrect or guides the learner to a corresponding material (Dempsey *et al*., 1993). For feedback to be effective, it should enable learners to learn from mistakes and correct errors or misconceptions (Brown and Glasner, 1999; Gibbs and Simpson, 2004; Ramsden, 2005). Furthermore, instructors should have means to be informed about the challenges their learners face. Many Computer-Aided Instruction (CAI) systems have been developed and investigated in the literature (De Bra and Calvi, 1998; Melis *et al*., 2001; Weber and Brusilovsky, 2001; Brusilovsky and Rizzo, 2002; Murray, 2003; Frith *et al*., 2004; Fraij, 2008; Fraij *et al*., 2010). In such systems, the delivery of learning material is personalized according to a learner model i.e., the learner is provided with a learning path that corresponds to his or her capability and knowledge.

The learning material is pre-stored and not changeable however the order in which course items are delivered keeps changing. Another crucial advantage of using CAI is the ability to provide immediate feedback to both learners and instructors. The study (Gill and Greenhow, 2008) showed improvements in the performance of the learners actively engaged with a CAI system which integrated feedback. This feedback was limited on the form of formative and summative assessments and did not employ the three generic feedback approaches. This study introduces a CAI system with effective feedback mechanisms for both learners and instructors and measures the impact of the system on learners in the field. The goal is to increase the learners engagement and to maximize the value of learners feedback to their instructors. The instructors are able to evolve the material to meet the learners' needs based on the generic feedback approaches. The system was tested on learners in the field and the results showed that it improved the performance of the learners.

MATERIALS AND METHODS

Based on considerations of previous research, a CAI system was developed to teach a mathematics course.

The system consists of two modules: the instructor module and the student module. These modules were supported by effective dual feedback mechanism. This mechanism aims at enriching learners feedback and maximizing the value of this feedback by instructors.

The effect of the system was measured on learners in an introductory mathematics, namely Mathematics for Classroom Teachers (I) (MCRTI). This course is offered at Al-Hussein Bin Talal University (AHU). The goal was to answer the following question: does effective feedback affect the performance of the learners? To answer this question, the learners were divided into three groups: control, experimental$_1$ and experimental$_2$. The learners in the control group were taught the course using traditional face-to-face approach. However, the learners in the experimental$_1$ group were given the advantage to practice on a traditional CAI system with limited feedback. Finally, the learners in the experimental$_2$ group were given the advantage to practice on the system developed in this study. The learners in the three groups were introduced to an achievement test prior to the beginning of the teaching process (pre-test) to ensure equivalency of the groups. To measure the impact of the system, the same achievement test was provided to the learners in the three groups by the end of the learning process (post-test).

Architecture of the system: The system consists of two modules, the instructor module and the student module. These modules are connected through a central database. It is noteworthy that the access to the system is controlled through a username and a password which is assigned to learners by their instructors. Figure 1 shows the overview of the architecture of system. The instructor module is in charge of uploading the course curricula, creating a test bank, planning lessons and analyzing the feedback of the students.

The lesson planner is a tool that is used by the instructor to determine the suggested structure and the sequence of the lessons of the course. The feedback analyzer provides the instructor with a summary of the students performance.

In the second module, students interact with the system through the display engine. Using the display engine, students can interact with the system using two modes: non-interactive and interactive. Figure 2 represents the flowchart of the high-level algorithm of the display engine. The engine enable students to view lessons, take the pre, post and final tests and submit comments, questions and feedback to their instructors.

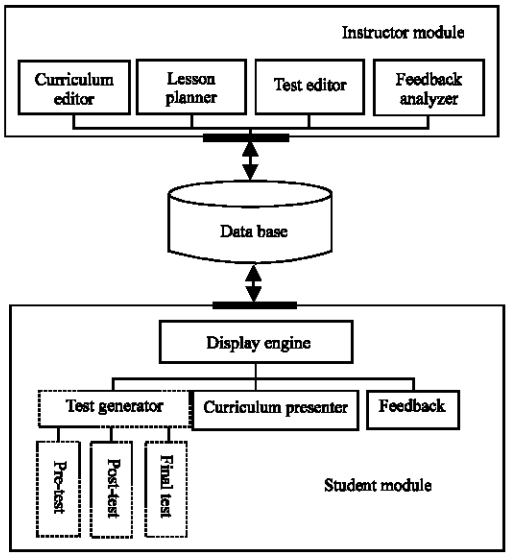

Fig. 1: The architecture of the system

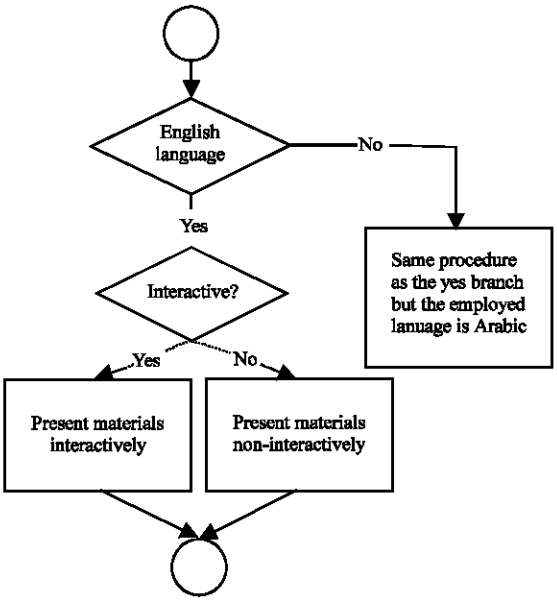

Fig. 2: Flowchart of the high-level algorithm of the display engine

Feedback mechanism: The feedback analyzer informs instructors about students performance and the challenging questions they face. It also informs the instructors about the accumulated ratings given by the learners to material.

This information can be used by the instructors to update the material in the system. It can be used further in the classroom to elaborate on material that corresponds to the challenging questions or material. The feedback

mechanism in the student module was integrated which includes knowledge of response, knowledge of correct response and elaborated feedback.

The feedback was either explicitly or implicitly. Implicit feedback informs learners about the status of their answers to test and exercise questions. Furthermore, it provides elaboration on the correct answers of challenging questions and suggests further readings. The explicit rating includes asking the learners to rate learning material associated with each topic. This feedback is provided to the instructor as earlier described. Figure 3 shown flowchart that illustrates the student feedback.

Participants: The number of learners who participated in this study was 46 undergraduate learners enrolled in the course in the spring semester of the academic year 2009.

This number of participants is reasonable as the average size of courses is 50 and some of the learners did not like to participate in this experiment.

Initially, the group members were introduced to achievement test prior to the beginning of the teaching process (pre-test). The goal of the test was two fold: first to ensure the equivalency and homogeneity of the three groups and second to measure the background of the learners in the group.

Achievement test: To ensure that the test represents the contents of the course, table of specification procedures was used.

The test was also given to three professors who taught this course and they were asked to judge the ability of the test items to represents the course material. Based on their comments the test was modified accordingly.

The reliability of the test was estimated using Cronbach Alpha formula and it was (0.864). Based on table of specifications, judges and Cronbach Alpha; the achievement test had enough evidence of reliability and validity to be used for the purposes of this study.

Procedure: To ensure the faithfulness of the results the three groups were assigned the same text book and were introduced to the same material concepts. Furthermore, the learners in the group were assigned similar homeworks and given similar quizzes and tests as a part of the teaching process.

By the end of the semester, the learners were introduced to the same achievement test that they were assigned at the beginning of the semester prior to the beginning of the teaching process. The end-of-semester achievement test is referred to as post-test.

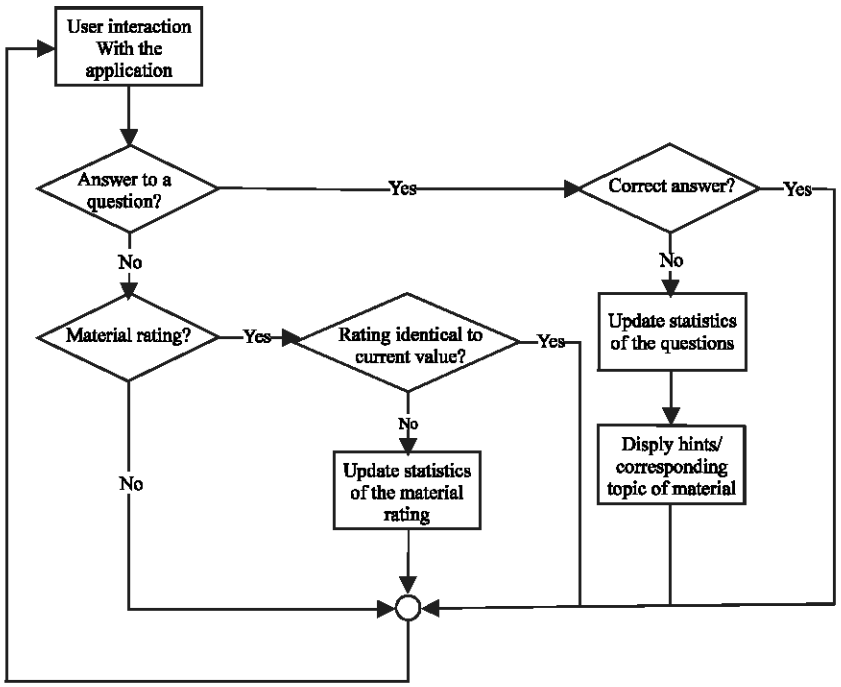

Fig. 3: Flowchart represents the feedback mechanism in the student module

RESULTS AND DISCUSSION

After being introduced to the pre- and the post-tests, the results of the learners in the groups were collected. Table 1 shows the descriptive statistics of the results of the pre- and post-tests for the three groups. The mean of the pre-test for the learners in the groups laid within the range 18.100 and 22.304. However, the mean of the post-test for the learners in the groups laid within the range 30.350-37.696.

To ensure, initially the equivalency of the three groups based on the results of the pre-test, one way ANOVA was used. The results shown in Table 2 indicate that there are no statistical differences among the groups at $\alpha = 0.05$. This suggests that the learners in the groups have comparable background in the material of the course.

To measure the equivalency of the groups based on the results of the post-test, one way ANOVA was also used as shown in Table 3. In the Table 3 the results of the comparison of the groups are illustrated. From the results, the groups are statically different at $\alpha = 0.05$. This suggests that learners in the groups varied in getting benefits from using the systems.

Based on the above discussion, the three groups of the learners were found to be equivalent based on the pre-test results. After conducting the experiments in this study, the learners in the $experimental_2$ group had achieved the highest average (higher than the control and $experimental_1$ groups). Furthermore, the comparison of the groups based on the results of the post-test revealed that the means of the three groups were statically different at ($p<0.001$). Thus, the system developed in this study has been proven to improve the learners performance. By going back to Table 1, $experimental_2$ has the highest mean ($\bar{x} = 37.696$) then $experimental_1$ ($\bar{x} = 34.74$) and the lowest is the control group ($\bar{x} = 30.35$). This indicates that the system presented in this study has helped the students to increase their learning compared with a traditional CAI system with limited feedback and the traditional teaching method.

Table 1: Mean and standard deviation of the pre and post-tests for the three groups

Test type	Groups	N	Mean ($\bar{x}$)	Standard Deviation (SD)
Pre	Control	40	18.100	8.177
Pre	$Experimental_1$	31	20.000	8.914
Pre	$Experimental_2$	46	22.304	7.155
Post	Control	40	30.350	8.684
Post	$Experimental_1$	31	34.742	8.869
Post	$Experimental_2$	46	37.696	8.374

Table 2: ANOVA results of measuring the equivalency of the groups based on the results of the pre-test

Statistical analysis	Sum of squares	DF	Mean square	F	Sig.
Between groups	380.969	2	190.484	2.977	0.055
Within groups	7295.339	114	63.994	-	-
Total	7676.308	116	-	-	-

Table 3: ANOVA result of comparing the performance of the three groups based on the results of the post-test

Statistical analysis	Sum of squares	DF	Mean square	F	Sig.
Between groups	1159.345	2	579.673	7.814	0.001
Within groups	8456.775	114	74.182	-	-
Total	9616.120	116	-	-	-

CONCLUSION

The results of this study have provided evidence that employing dual feedback in CAI in blended learning to teach an introductory mathematics course improves the learners performance. The students obtained rapid, effective feedback from the system. The system on its turn, provides instructors with knowledge about learners challenging topics. This information is used by the instructors to update the learning material both in the classroom and via the system. The results of the study will motivate the building of a generic CAI system based on the introduced system. This system will be course independent and can be used to aid-teaching any course.

REFERENCES

Brown, S. and A. Glasner, 1999. Assessment Matters in Higher Education: Choosing and using Diverse Approaches. Open University Press, Buckingham.

Brusilovsky, P. and R. Rizzo, 2002. Map-based horizontal navigation in educational hypertext. Proceedings of the 13th ACM Conference on Hypertext and Hypermedia, June 11-15, ACM, New York, USA., pp: 1-10.

Clark, K. and F.M. Dwyer, 1998. Effects of different types of computer-assisted feedback strategies on achievement and response confidence. Int. J. Instructional Media, 25: 55-63.

De Bra, P. and L. Calvi, 1998. AHA! An open adaptive hypermedia architecture. New Rev. Hypermedia Multimedia, 4: 115-139.

Dempsey, J.V., M.P. Driscoll and L.K. Swindell, 1993. Text-Based Feedback. In: Interactive Instruction and Feedback, Dempsey, J.V. and G.C. Sales (Eds.). Educational Technology Publications, Englewood Cliffs, pp: 21-54.

Foote, C., 1999. Attribution feedback in the elementary classroom. J. Res. Childhood Educ., 13: 155-166.

Fraij, F., 2008. Visual and interactive computer-based software for teaching a mathematics course: An approach. Proceedings of the IEEE Conference on AI Tools in Engineering, Pune, India.

Fraij, F., M. Al-Quraan, A. Dababseh and S. Al-Obedi, 2010. The impact of employing technology in teaching a mathematics course. Int. J. Innovation Learning (IJIL), Vol. 8, No. 2.

Frith, V., J. Jaftha and R. Prince, 2004. Evaluating the effectiveness of interactive computer tutorials for an undergraduate mathematical literacy course. Br. J. Educ. Technol., 35: 159-171.

Gibbs, G. and C. Simpson, 2004. Conditions under which assessment supports students' learning. Learning Teaching Higher Educ., 1: 3-29.

Gill, M. and M. Greenhow, 2008. How effective is feedback in computer-aided assessments?. Learning Media Technol., 33: 207-220.

Mavrikis, M. and A. Maciocia, 2003. WALLIS: A web-based ILE for science and engineering students studying mathematics. Proceedings of the 11th International Conference on Artificial Intelligence in Education, (AIE'03), Sydney, Australia, pp: 505-512.

Melis, E., E. Andres, J. Budenbender, A. Frishauf and G. Goguadse *et al.*, 2001. ActiveMath: A web-based learning environment. Int. J. Artificial Intel. Educ., 12: 385-407.

Mory, E.H., 2004. Feedback Research Revisited. In: Handbook of Research on Educational Communications and Technology, Chapter 29, Jonassen, D.H. (Ed.). Lawrence Erlbaum Associates, New Jersey, pp: 745-783.

Murray, T., 2003. MetaLinks: Authoring and affordances for conceptual and narrative flow in adaptive hyperbooks. Int. J. Artificial Intel. Educ., 13: 199-233.

Ramsden, P., 2005. Learning to Teach in Higher Education. 2nd Edn., Routledge, London.

Warden, C.A., 2000. EFL business writing behaviors in different feedback environments. Language Learning, 50: 573-616.

Weber, G. and P. Brusilovsky, 2001. ELM-ART: an adaptive versatile system for web-based instruction. Int. J. Artificial Intel. Educ., 12: 1-35.