# An Empirical Study on E-learning Note-Taking Platform Using Multimodal Metaphors

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***Abstract*—**This paper introduces an empirical study to investigate the effect of including multimodal metaphors such as text, graphic and speech in e-learning application. The aim of the experiment was to measure and compare the level of usability of textual and multimodal interfaces. The usability parameters which are efficiency, effectiveness, and users' satisfaction were considered in the study. In order to carry out comparative investigation, two independent groups were involved to evaluate two different interfaces of an experiment e-learning platform. First group (control) was consisted 22 participants using textual interface platform based on textual modal only. This platform used Microsoft Word 2007 and its 'adding comments' feature as the modal. The second platform was based on a multimodal interface used by the experimental group and consisted of three multimodality tools to improve efficiency of e-learning. The modalities used by this experimental group were text, speech and graphics. The results obtained from this investigation have shown that the multimodal e-learning interface group increased the level of usability by taken lower time to complete the experimental tasks and performed successfully higher number of tasks, and more satisfied than the textual interface group. However, the error rate in the experimental group was found to be greater than that of the control group. The results also suggested that other multimedia metaphors could be used for enhancement and improvement the performance of e-learning system. These metaphors could include the use of combinations of graphic, recorded speech and earcons.

***Keywords*—** E-learning, Usability, User interface, Multimodal Interaction**.**

## I. INTRODUCTION

Computers nowadays play the most important part in our lives[1]. In the education system, for example, the use of the computer is becoming very important. The e-learning is also considered one of the main facilities that should be available for students to help them in their education[1, 2].

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As more and more institutions are relying on presenting their material online, the necessity to present this material in a more efficient way has also increased[3, 4]. The development of information and communication technology available provides a great opportunity to extend the knowledge and skills of individuals[5, 6]. The reliance on this medium has increased almost exponentially with the popularity of the internet. In order to make good use of this resource we also require a tool to present to us this information in a way that can be understood and used more easily.

However, the method of transference of this information from the screen to the user has remained largely unchanged, in that the communication has only been visual[7]. It has been shown that overuse of textual information is not the most effective method of learning online[8]. Other human senses, if used alongside the visual sense, can greatly assist in understanding the presented information[9]. Some of these include metaphors such as speech, recorded sound and graphics, to name a few[10]. Two user groups were set up; one control group using textual only interface and the other experimental group using a multimodal interface consisting of speech, graphic and added text with the objective to measure usability and advantages of these metaphors within an e-learning tool to aid learning. The experimental study discussed in this paper was intended to investigate the use of multimodality to assist in e-learning applications for the context mentioned above.

## II. E-LEARNING

### A. What is E-learning

In the internet world, it has become common to use the prefix 'e' to create a new word with a different meaning such as in e-commerce in another word electronic commerce, e-banking, electronic banking and e-mail, electronic mail, etc. The 'e' refers to the use of internet [6]. Rosenberg (2001, P: 28) argues that "e-learning refers to the use of the internet technologies to deliver a broad array of solutions that enhance knowledge and performance" [11]. He adds that e-learning "is based on three fundamental criteria":1) It is networked, which makes it capable of instant updating, storage, distribution and the sharing of instruction or information. 2) It is delivered to the end-user via a computer using standard internet technology[8, 12]. 3) It focuses on the broadest view of learning – a learning solution that goes beyond the traditional paradigms of training.

E-learning can be classified into four categories: Computer-based learning, online learning[13], web-based learning and distance learning[14]. Computer-based learning is the term for self-study using a computer, often with CD-ROM and self-tests[15]. Online learning has to do with online study with or without instructors[16]. Web-based learning refers to the use of both technology and traditional methods in learning[17]. Distance learning refers to study using several methods for example TV, Radio, CD-ROM and some different technology[18, 19].

### *B. Why E-learning*

The technology of web-based can offer more chances for people who seek to learn with little income for whom the payment of traditional course fees is difficult[20]. And time is also important for those with full time employee who cannot attend traditional class at specific time. Because of that e-learning has offered many people the chance to learn and educate them self[21].

Web-based learning has offered different ways to deliver courses and thus makes electronic resources available to people[22]. E-learning can be applied to either synchronous (same time but different place) or asynchronous (different time and different place) learning.

Synchronous learning

In this type of e-learning the students go to class via computer and ask questions and get answer by e-mail or in real time live chat. This type of learning seems more active to students since it creates an atmosphere similar to that in the traditional classroom[23].

Asynchronous Learning

In this type of e-learning, the students participate with other students and instructor, although they are not at the same time. They attend the class at any time they need to and this approach of learning allows support and feedback to be given by instructor and classmates, providing that the course material is limited in a specific time[24].

E-learning is still an emerging field, and gives many benefits that are totally different from a conventional classroom based learning environment and can generate results for students[25]. The electronic technologies offer a wide range of benefits like standardisation, cost-effectiveness, flexibility and scalability. The benefits of e-learning are summarised[19, 26]: 1) Contents could be easily kept up-to-date, because the information always comes from one central source. 2) Course materials are available at any time and from any place. 3) There are links to other websites for additional explanations and help. 4) The students are able to communicate with their instructors and anther classmates. 5) Students are able to plan the learning program according to their strengths and weakness.

## III. MULTIMEDIA METAPHORS

Research has shown that using more than one human sense in the learning experience allows people with different learning styles to absorb the presented information more effectively[27, 28]. Experiment conducted in this area shows that a typical student's learning style consists of 29% using visual metaphors, 34% using auditory metaphors and the remaining using haptic metaphors[29]. Therefore it can be concluded that there is a link between multimodal interfaces and improved learning[10, 28].

With institutions relying on delivery of their materials online, it has become only too obvious through research into human learning behaviors that multimodality will also play a major role in this evolution[30]. The use of multimodality has been in use in some in places already with positive results such as interactive simulations and online training modules on offer by educational institutions[30, 31]. Application of these can be seen where for example Microsoft have a series of educational material on Administration of their Operating Systems in which graphical and speech modals are applied to assist learning. Ebay also offer interactive courses teaching members of effective buying and selling processes and have concluded that using multimodality to deliver this course has far greater effectiveness than just textual instructions[32]. In addition, the human short-term memory, which is used by the learning process, has limited capacity and therefore reducing the amount of textual information by adopting multimodality improves its efficiency to retain what it has learnt[32].

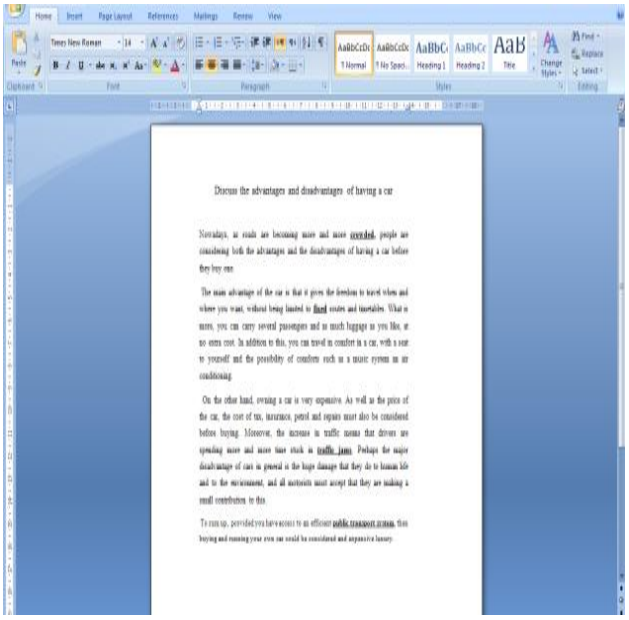
Furthermore, it has also been proven that providing a multimodal learning environment makes learning more exciting and fun as learners enjoy interaction whilst being taught rather than boring textual delivery of information[33].

### *A. Anticipated Benefits*

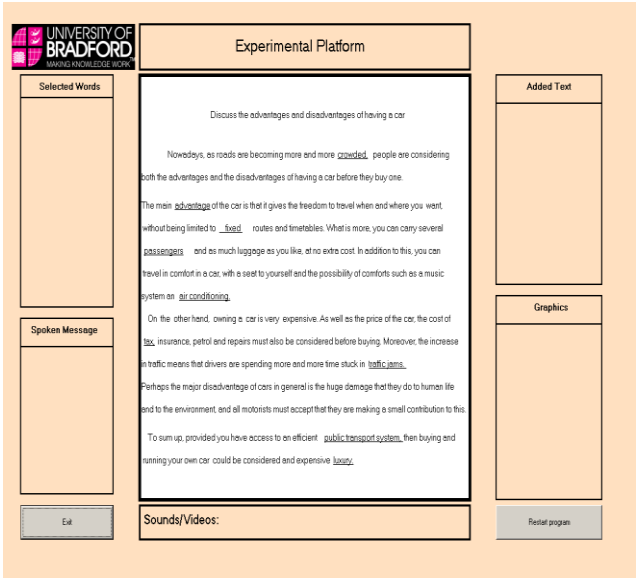
According to the literature studied, use of multimodality can influence students learning[34]. As e-learning applications are widely used the expected benefits of using multimedia in e-learning systems, in particular within the area of not-taking will result in improving the student performance by reducing the required time to complete the required tasks with fewer errors and to enhance student understanding and satisfaction[35]. Also, it will provide additional usability guidelines for development of multimodal metaphors in e-learning applications.

## IV. EXPERIMENT PLATFORM

The aim of this experiment was to investigate the effect of using multimodal metaphors in e-learning interfaces. The experimental setup was done on two platforms. The first platform used by the control group used only the textual modal. This platform used Microsoft Word 2007 and its 'adding comments' feature as the modal.



Textual Interface




Experimental Interface

The second platform was based on a multimodal interface used by the experimental group and consisted of three multimodality tools to improve efficiency of e-learning. The modalities used by this experimental group were text, speech and graphics.

Each multimodal from the above mention was tested in three tasks. In text interface the required information was to made note about specific word. For example, the participant was asked to select a word after reading the text and then write some notes which related to the word selected. The same steps of adding text was used in the second required but adding notes by text were removed and replaced with adding notes by graphic. For example, curse the mouse on the right word and then right-click to display a menu of options and choose add graphic then from the graphic box the user had to insert image or to do his/her own graphic note which related to the word selected. The same design of adding text and adding graphic were used in the last task which made note by speech (recorded speech). The purpose of using this metaphor was to reducing the overload on users' visual channel and enabling them to employ both of visual and auditory senses in obtaining the notes information.

### *A. Participants*

Forty-four participants, consisting of under-graduates and post-graduates were selected to investigate the effect of including multimodal metaphors usability of e-learning interfaces. Undergraduate and post-graduate were recruited from various departments with the help of staff members. The participants were divided into two independent groups, each group consisted of 22 users. A post-experimental questionnaire at the end of the experiment was answered by all participants. Participants were approximately 25% of them had a bachelor's degree, about 25% had doctor's degree and the remaining percentage had master degree 50%. The participants have been grouped into three categories on the basis of age. The majority are aged between 18 and 21 years old (20%) followed by those between 25 and 34 (40%) and the remaining percentage was over 35 years old. The average genders of participants were 85% male and only 15% were females. The reason for a low number of female participants was due to scarcity of females meeting the criteria of English as a second language and some basic computer competency. The participants also had a scientific background and they were using the experimental platform for the first time. Figure 1 show that the average number of participants who have limited knowledge about human computer interaction in the experiment was 40% and the number with good knowledge about 15%, about 45% had no knowledge.

In order for the experiment to be successful, all participants had to fulfill a certain set of criteria. The requirements were

a) computer literate background (i.e. used computers for more than 10 hours a week),

b) had not used the experimental platform before.

c) spoke English as second language.

### *B. Methodology*

Three criteria were chosen for measuring the level of usability of the two interfaces: effectiveness, efficiency and users' satisfaction. The effectiveness was measured through the number of error made by users about the interfaces and the metaphors and the efficiency was measured through the time which they spent in each task and the overall experiment. In addition, they were required to also complete a satisfaction questionnaire after performing all tasks. This questionnaire was scored 1- 6 on the Likert Scale with eight statements, which fitted all experimental conditions, and the users were required to specify their agreement to these statements. These statements were mainly about the ease of use, ease of learning and usefulness of each metaphor.

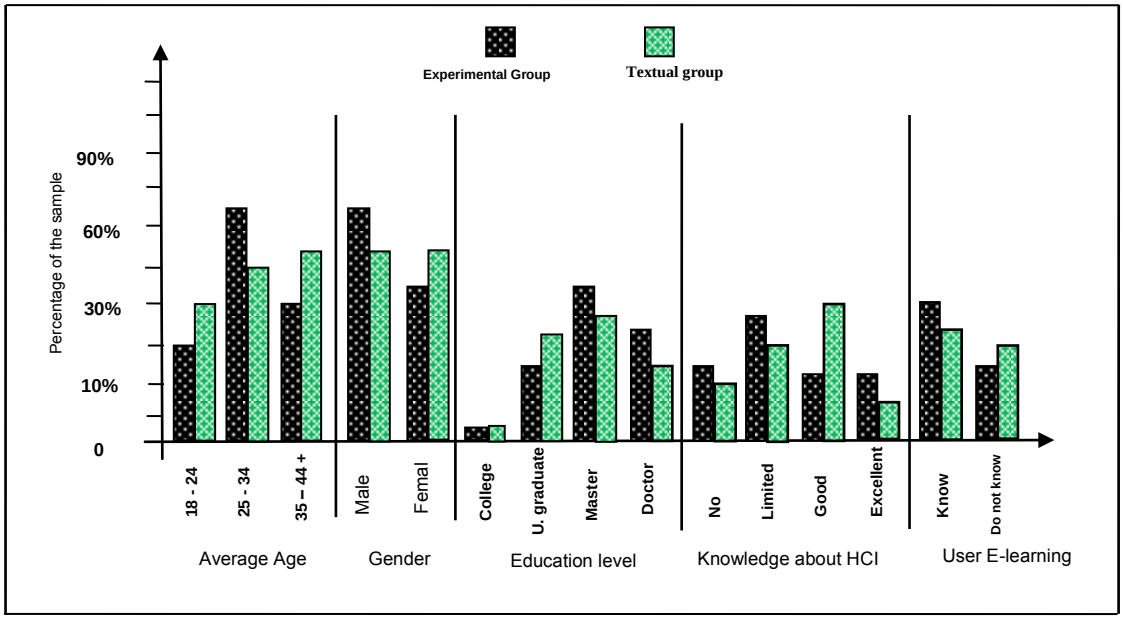



Figure 1. The average age gender and Education level

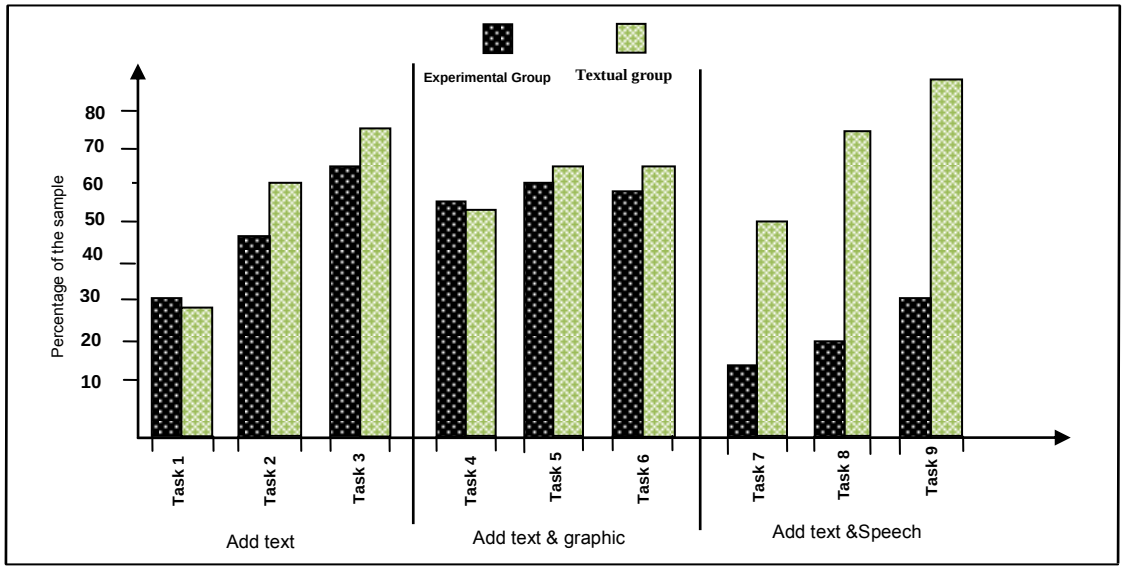



Figure 2. The mean values of task completion time for all tasks

### C. Tasks

The overall experiment consisted of nine tasks grouped into three sets of three tasks for each of the participants to complete. These tasks were designed with the objective of testing all the 3 different modalities listed above for the experimental group. For the control group users the steps were exactly the same for each task. They were given a set of pre-selected words and some notes to add as comments for them. For the experimental group each task was comprised of a set of steps which asked the users to place the mouse cursor over a selected word and highlight that word. Then the users had to right-click the word and select an option from a menu depending on the task they were required to carry out. For the first task the experimental group users selected the 'Add text' option from the menu. The second task required the users to select the 'Add graphic and text' option and the third required selecting the 'speech' option.

Each group had to do this for 3 words in each of the tasks. During the completion of the requirements, the time taken to perform the tasks and errors while performing the tasks was measured.

### D. Procedure

In the experiment the participants were divided into two separate groups; the experimental group used the multimodal interface and the control group used the textual interface. Each group consisted of 22 users and they were randomly assigned to one of the two groups. The users were briefed on the procedure and then given approximately ten minutes to read and understand the text they were expected to use in the experiment. Further, a quick demonstration of the procedure was given to ensure all participants fully understood what was required from them.

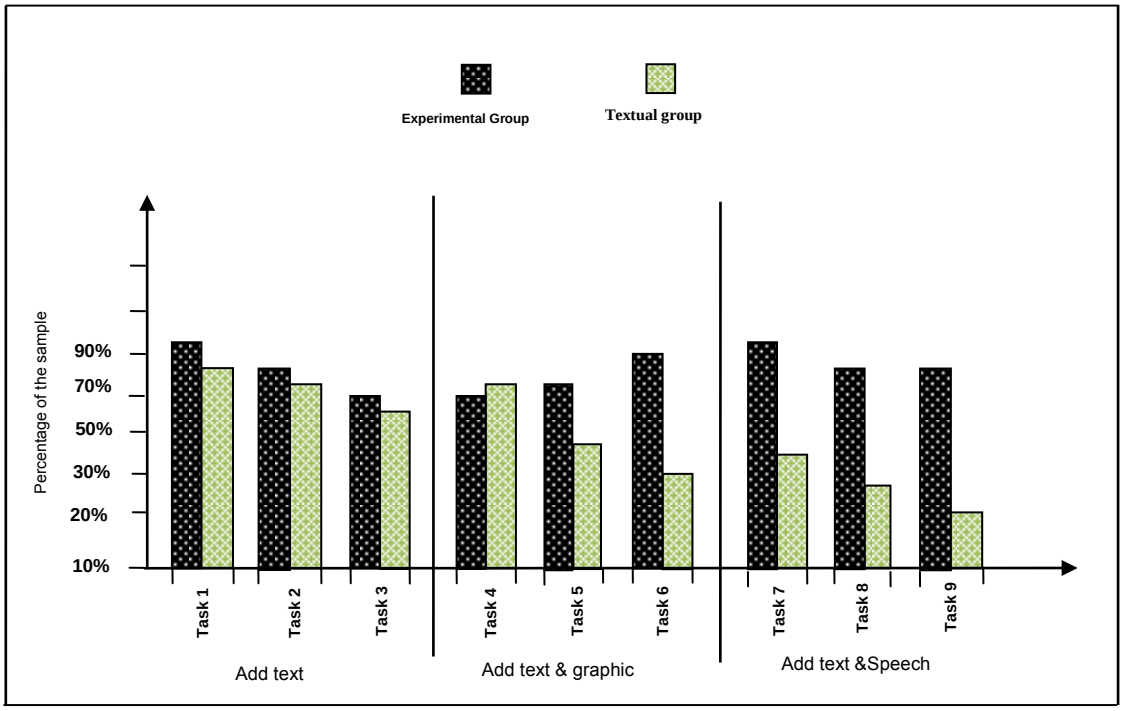



Figure 3. Percentage of successful completed tasks in both control group and experimental group

This time spent was not included in the timings for the actual experiment. Each of the users had to individually accomplish each of the specified tasks. The experiment time was recorded for each individual task and also for the overall experiment. The efficiency and frequency of errors were also recorded for all tasks. Efficiency was measured by timing how long a user took in completing each task. In the end the participants were asked to answer the satisfaction questionnaire. Post experimental questionnaires were designed to ask the control group to identify multimedia metaphors that they would have preferred as part of an e-learning system to improve efficiency and the experimental group were asked to identify those metaphors that they found most useful in their interaction with the e-learning experimental platform.

## V. Results and Discussion

### A. Task Completion time

The efficiency was defined as the total number of time taken to complete the tasks and overall experiment in each group, total time which the user spent looking for information. The performance of each user was observed, then recorded and noted in an evaluation form. Figure 2 shows that the mean completion time for all tasks in experimental group was lower than the control group.

The overall mean completion time for all tasks was significantly lower in the multimodal interface group in comparison with the textual interface group ($t = 2.42$, $cv = 1.65$, $p<0.05$). The main reason of this result was that the multimodal interface involved more modality such as speech, text and graphic. The percentages of task completion time for the control and experimental groups were both used text the experiment group performed slightly better. However, there was a noticeable difference when the experimental group used multimodality such as speech and graphic. This difference was found to be more significant between the task where experimental group was using graphic ($t = 2.30$, $cv = 1.65$, $p<0.05$) and speech ($t = 3.49$, $cv = 1.65$, $p<0.05$). During the experiments, it was observed that the time needed to perform the tasks in the experimental group was lower in used multimodal metaphors. As with time spent, mouse clicks were performed with the two experimental interfaces. The result of the experiment showed that users of the multimodal interface had more mouse clicks than users of textual interface. The number of mouse clicks recorded for the text, graphic and speech tasks was in text 4 clicks in each task, graphic 5 and speech 8 while the total number of mouse clicks performed for the completion of task in textual interface was 4. High statistically differences were recorded when comparing the time spent performed between the multimodal interface and textual interface.

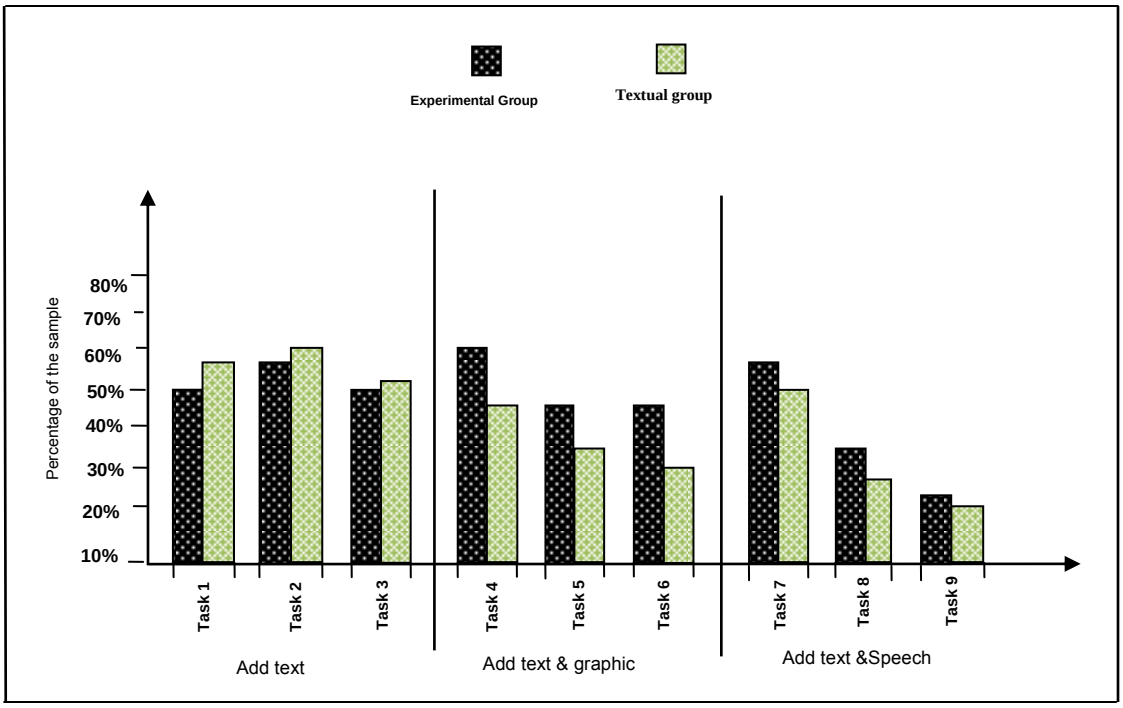



Figure 4. The average number of errors in each task

### B. *Successful Completion of Tasks*

The performance of each user was checked and total number of completion tasks for each user in each group was obtained and then used for statistical analysis. The total number of performed tasks in both group was 198 (22 multiply by 9 tasks in each user) Figure 3 shows that the users of experimental group managed to complete tasks successfully more than users of the control group. Users in the experimental group completed 188 tasks (95%) while users in the control group completed 154 tasks (78%).

In the last three tasks where the experimental group used speech and control group used text, percentages of successful completed task were much better in experimental group than the control group. The difference in completion time between the groups increased as the experimental group tasks involved multimodal metaphors.

### C. *Satisfaction*

Users were asked also to select their preferred interface and provide an explanation for their choice. These ratings were used to analyse the level of users' satisfaction of the two interfaces in regard to different aspect (ease of use, confusion, nervousness, ease of learning and overall satisfaction) in both interface versions. This questionnaire was Six points Likert scale. Users' satisfaction of the interfaces was evaluated by obtaining users' views of each individual metaphor and interface used.

These points were used for each statement in the questionnaire ranging from 1, the value for strongly disagree, to 6, the value of strongly agree. T-test was performed on the total number of scores to test the difference in users' satisfaction. The result showed that multimodal interface was significantly more satisfactory than textual interface ($t = 2.62$, $cv = 1.65$, $p<0.05$).

From the viewpoint of users' views, the interface versions were very similar with respect of ease of usability and this led to some amount of nervousness. The results show that ease of use was greater with the multimodal interface but greater difference was observed in statements connected to the learning process. Mmultimodal interface users found it easier to learn. Also, the results of post experimental questionnaires which were designed to ask the control group to identify multimedia metaphors that they would have preferred as part of an e-learning system and the experimental group were requested to express preference for particular types of multimodal metaphors that they found most useful in their interaction with the e-learning show that almost of participants who involved in the experimental group preferred the application with multimodal metaphors in order it was first prefer speech followed by graphic and then text. Also high percentage of participants who involved in the control group preferred to have multimodal metaphors in the e-learning application.

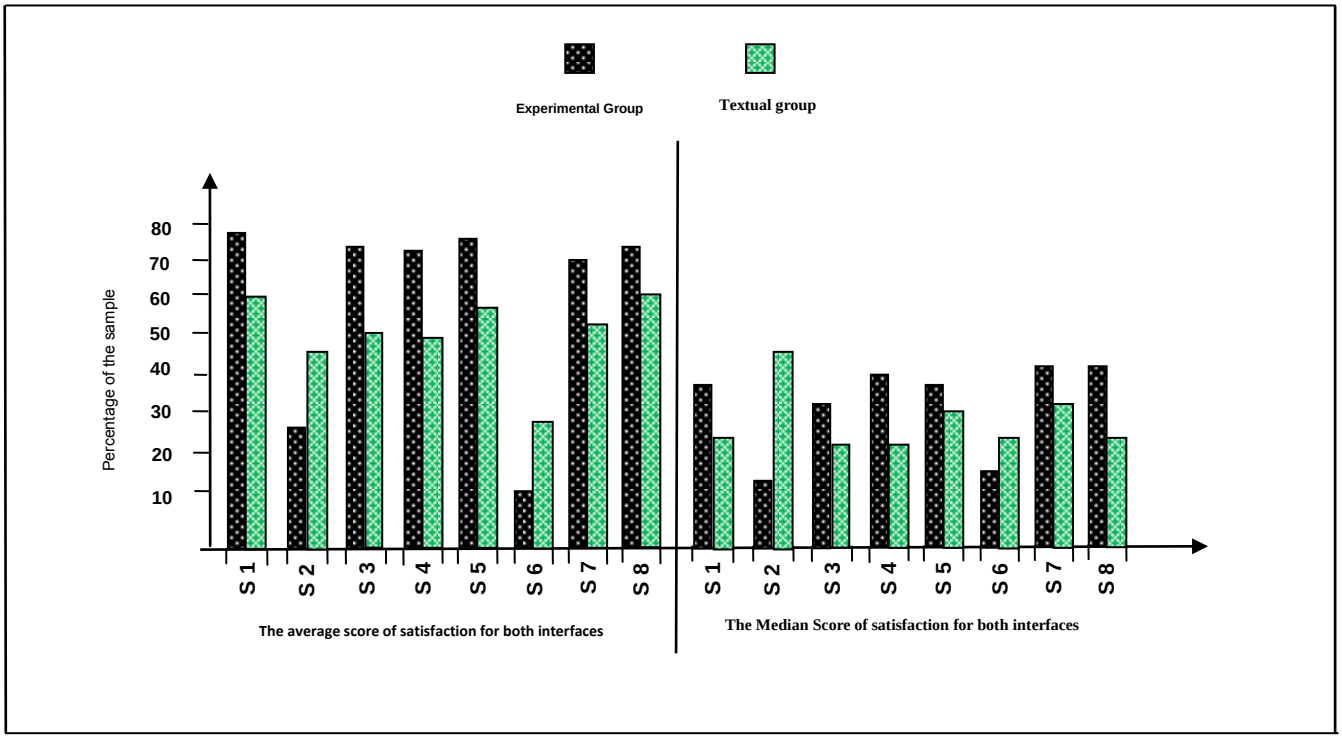



Figure 5. The average and the Median Score of Satisfaction

## VI. Conclusion and Future Work

This paper has shown that when incorporating recorded speech, graphic and text can improve the efficiency of e-learning applications. The overall time taken to complete the required tasks was significantly less when these multimodal interaction metaphors were utilised to communicate information about electronic notes or information. Figure 4 shows the error rate in the experimental group was found to be greater than that of the control group. The reasons for this are: a) The experimental interface is more involved applications. b) There are more mouse clicks involved in the experimental interface. c) Users are more familiar with the Microsoft Word application. Future work will involve investigations around methods of reducing the errors of the experimental group, such as clicking the correct buttons on the screen for the graphics and speech part of the experiment. Furthermore, earcons will be designed, developed and tested to observe the influence and effects they have on learning. The contribution of speech has been valuable, therefore other ways in which this particular metaphor can be incorporated will also be investigated, for example the use of pre-recorded speech.

## References

[1] A. S. Molnar, "Computers in Education: A Brief History," *THE Journal (Technological Horizons In Education)*, vol. 24, 1997.

[2] S.Alexander, "E-learning developments and experiences," 2001.

[3] S. Naidu, "Designing and Evaluating Instruction for e-Learning," *Designing Instruction for Technology-Enhanced Learning*, 2002.

[4] B. Dahlbom and L. Mathiassen, "The future of our profession," *Communications of the ACM*, vol. 40, pp. 80-89, 1997.

[5] L. Kvasny and D. Truex, "Defining away the digital divide: A content analysis of institutional influences on popular representations of technology," Realigning research and practice in information systems development. Social and organizational perspective," 2001.

[6] M. Paiting, ""E-learning: is it really the best thing since sliced bread,"", 2002.

[7] V. Jones and J. H. Jo, "Ubiquitous learning environment: An adaptive teaching system using ubiquitous technology," *Beyond the comfort zone:*

*Proceedings of the 21st ASCILITE Conference*, pp. 468-474, 2004.

[8] M. J. Rosenberg, "E-learning-strategies for delivering knowledge in the digital age," 2001.

[9] S. A. Brewster, "Using non-speech sound to overcome information overload. Displays," 1997.

[10] D. a. D. H. Rigas, "The Role of Multimedia in Interfaces for On-Line Learning.," 2003.

[11] J. M. Rosenberg, "E-Learning: Strategies for Delivering Knowledge in the Digital Age.," 2001.

[12] R. Hamilton, C. Richards, et al., "An examination of e-learning and e-books," 2001.

[13] M. Nichols, "A theory for eLearning," *Educational Technology & Society*, vol. 6, pp. 1-10, 2003.

[14] T. Bates, *Technology, e-learning and distance education*: Routledge, 2005.

[15] J. McGovern and K. Gray, "Directions for organisation and management of university learning: Implications from a qualitative survey of student e-learning," *Proceedings of ASCILITE 2005*, 2005.

[16] J. C. Richardson and K. Swan, "Examining social presence in online courses in relation to students' perceived learning and satisfaction," *Journal of Asynchronous Learning Networks*, vol. 7, pp. 68-88, 2003.

[17] R. D. M. A.Gunasekaran, and D. Shaul, , "E-learning: research and applications, Industrial and Commercial Training," 2002.

[18] J. Kurhila, M. Miettinen, P. Nokelainen, and H. Tirri, "Use of Social Navigation Features in Collaborative E-Learning," *E-Learn*, 2002.

[19] C. J. Bonk and R. A. Wisher, "Applying collaborative and e-learning tools to military distance learning: A research framework," *US Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA., Technical Report*, 2000.

[20] H. R. Pfister and M. Mühlpfordt, "Supporting discourse in a synchronous learning environment: The learning protocol approach," *Proceedings of the Conference on Computer Supported Collaborative Learning (CSCL)*, pp. 581-589, 2002.

[21] G. Singh, J. O'Donoghue, and H. Worton, "A study into the effects of elearning on higher education," *Journal of University teaching and learning practice*, vol. 2, pp. 13-24, 2005.

[22] A. P. Rovai, "Sense of community, perceived cognitive learning, and persistence in asynchronous learning networks," *The Internet and Higher Education*, vol. 5, pp. 319-332, 2002.

[23] C. Zheng and G. D. Bennett, "Applied Contaminant Transport Modeling," *Industrial and Commercial Training*, vol. 34, pp. 256-262, 2002.

[24] K. O'Neill, G. Singh, and J. O'Donoghue, "Implementing eLearning Programmes for Higher Education: A Review of the Literature," *Journal of Information Technology Education*, vol. 3, pp. 313–323, 2004.

[25] F. a. L. A. Mikic, "Towards a Standard for Mobile E-Learning. International Conference on Systems and International Conference on Mobile Communications and Learning Technologies, 2006. ICN/ICONS/MCL 2006. International Conference on Networking,," 2006.

[26] D. Murray, "e-Learning for the Workplace: Creating Canada's Lifelong Learners," *Conference Board du Canada*, 2001.

[27] G. shaw and N. Marlow, "the role of student learning styles, gender, attitudes and perceptions on information and communication technology assisted learning,," 1999.

[28] A. j. Dix, "Human-computer interaction," 1993.

[29] D. G. a. V. J., "The learning Revolution, The Learning Web, Torrance, CA, USA," 1999.

[30] S. L. N. a. E. P. G. Megan L. Brown, R. P. Institute*, and N. Troy, "An Experiment into the Use of Auditory Cues to Reduce Visual Workload," 1989.

[31] D. R. a. D. Hopwood, "The Role of Multimedia in Interfaces for On-Line Learning," 2003.

[32] S. Graf, T. Lin, and Kinshuk,. Seventh IEEE International Conference on Advanced Lerning Technologies " Analyxing the relationship between leearning styles and cognitive traits," 2007.

[33] G. A. A. Dix, J. finlay and R. Beale, , "Human-computer interaction ", 2004.

[34] N. B. Sarter, "Multimodal information presentation: Design guidance and research challenges,," 2006.

[35] R. Wagner, J. Werner, and R. Schramm, "An evaluation of student satisfaction with distance learning courses," 2002.