Learning Object: An Effective E-Learning Tool for Computer Program

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Abstract: E-Learning is an effective and efficient means for learning in recent years. Content is one of the key aspects of e-Learning where quality plays the main role. This paper concentrates on the qualitative features required for an effective e-Learning tool and demonstrates the potential of interactive visualization tools developed under the Codewitz Asialink project for teaching and learning computer programming techniques. The visualization aids are then integrated with the programming courses. Survey on the use of visual aids in the classroom or independently by the students has shown that the students can learn the programming techniques more effectively than the traditional learning approach.

Introduction

E-Learning is not just another presentation of learning. Fast growth of the Internet technologies has transformed it into a new opportunity which has redefined the vision and scope of teaching and learning. The span of transformational possibilities is so wide that it demands modification of the entire educational system of our civilization (CEC 2000). Though the e-Learning industry has emerged only over the last couple of years, it is highly focused and fragmented into many areas. It can, however, be broadly classified into three main categories: Content, Services and Technology (AFLF 2004). Each of these aspects can be studied separately in depth. In this paper we concentrate on the key features that a good content should possesses, which is then followed by the presentation of a practical e-Learning aid, referred to as *Learning Object* (LO) (Rahman et al 2007).

The problems in teaching and learning programming techniques prevail all over the world. Learning programming logic without utilizing any visualization material is really tough (Robins et al ; 2003; Lahtien et al; 2005). To improve the teaching and learning environment, development of novel and appropriate learning aids are therefore highly relevant (Naps et al 2003). Numerous visualization tools (LMU, Pickard et al;2003; Bradley & Boyle; 2004; Morenoet et al ; 2004; Virtanen et al ; 2005) are already available for beginners in programming. These visualizations are capable of providing a more conducive learning environment if they are used effectively.

The university, where the authors are affiliated with, has become an active partner in the global e-Learning program through the Codewitz Asialink project (Codewitz 2004). The goal is to plan, produce and evaluate unique illustrations, animations and visualization aids for students and teachers of computer programming. Even if the use of visualizations has increased in introductory programming, the visualizations are still integrated in the course content. In partnership with Tampere Polytechnic of Finland, a four-party collaborative team developed a considerable number of LOs, which are significantly different from some of the existing learning aids in terms of pedagogic principles incorporated into their design. The LOs were then integrated with the courseware in the partners' institutes. The results of the survey showed that students who used LO's performed better than students who did not use them.

Quality Factors of an E-Learning Content

Content is one of the most important aspects of e-Learning. Content's selection, analysis, design and presentation create a comprehensive learning experience. While there are numerous e-Learning solutions available today, the factors that help learners achieve a superior learning experience and motivation should be emphasized in the content development process (Kheterpal 2005). Content developed for e-Learning should address the following desirable properties.

Relevance of the Content

Relevance of the content is vital. The theme of the content should be timely and relevant so that it is appropriate within the context of its environment. Additionally, the content should have a positive impact on the global community.

Interactive and User-friendly

E-Learning tools are developed such that they are suitable for self-learners. The modules should thus make things easier and attractive to the user. To be appropriate for independent practice, the modules should be interactive for the learners, and free from the hassle of password requirement.

Appropriate to Learner Type and Needs

When developing learning tools for different learners, it is important to consider learner needs and the context in which they would be used. One important aspect can be the multilingual capability embedded within the tools. Sometimes the topic is new and the learners are unable to understand the content developed in foreign languages. A more practical approach would then be to design the content with multilingual usability. This can be achieved through proper interface design, effective presentation mechanism based on different lingual perspective.

Self-containing and Self-explanatory Visuals

The e-Learning modules should be as self-contained. External sources (e.g. web link) will diminish the attention of learners, especially when the theme of the content is very technical.

Step-wise Instructions with Animations

Step-wise instructions and display are very much useful in visualization tools, especially for the tools simulating programming, whereby for certain topics where every single statement carries a specific operation.

Supporting Audio-video Files

Context sensitive audio files and video clips can be included to e further illustrate the underlying module. This can add extra values to a content to be self-contained and self-explanatory.

Continual Improvement

Teaching/ learning using the e-modules creates an environment where instructors/ learners can make comments to improve the quality of the content. Developers can update the contents accordingly. So there should be provision for continual improvement.

Learning Object: A Paradigm of E-Learning Tool for Computer Program

Within the Codewitz network, the LOs are defined as visual tools for learning that are browser capable, stand-alone, reusable, and not linked to any other LOs or resource and are focused on specific learning goal. The LOs are based on visualizing programming logics and suitable for exercising.

The idea of LOs resembles with a debugger which shows step-by-step program execution in both forward and backward directions. The program-code is highlighted in each meaningful step of execution. Every step of program execution is visualized at the same time in the memory area *Visualization Window*. An *Information Window* is also included for explaining the statement sensitive information. The memory area is the only part where the layout can be changed according to the subject-matter of the underlying program. This change appears, for example, in case of array when the structure of the array is visualized. An LO based on a first-day *C* program for adding two integers is shown in Fig. 1. As seen in the figure, declaration of three variables *a*, *b*, and *c*, is depicted by visualizing three memory boxes in the visualization window, which is then followed by stepwise appropriate visualization of value assignment to *a*, *b*, and *c*. Another LO depicting a relatively complex problem using *for* loop is shown in Fig. 2. This example derives substring from a string starting from a given position and length. Visualization of the loop variables together with the process of copying characters to a second array provides a clear understanding of the logical flow of looping structure. Different set of input can also be exercised by moving the flow of execution back and forth, which additionally gives an interactive learning environment to the students.

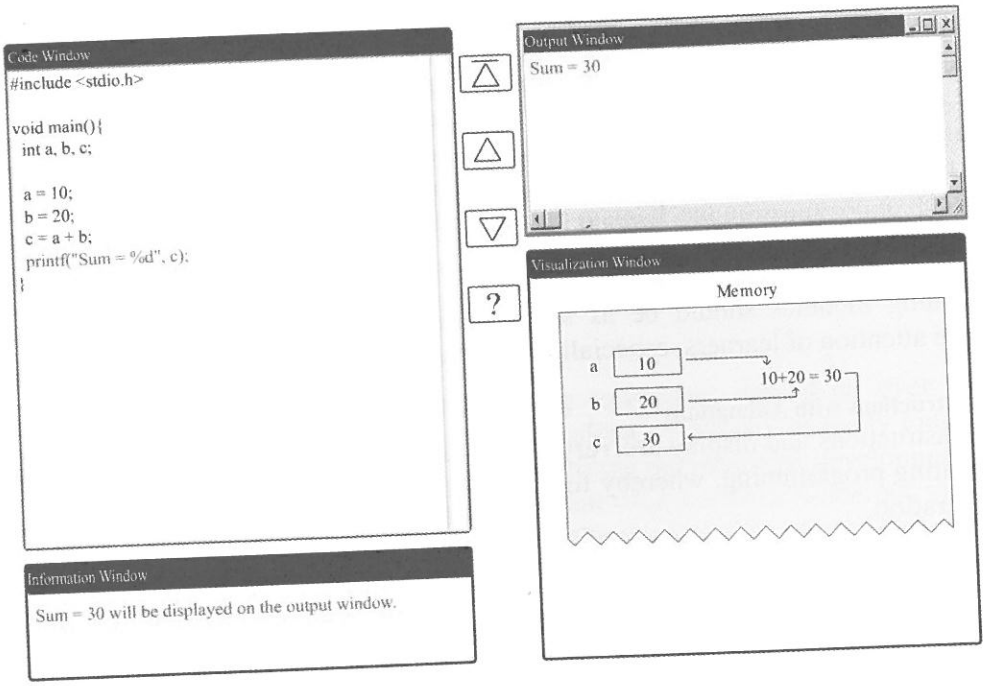

Fig. 1 Learning Object on a very Basic *C* Program for Adding Two Numbers

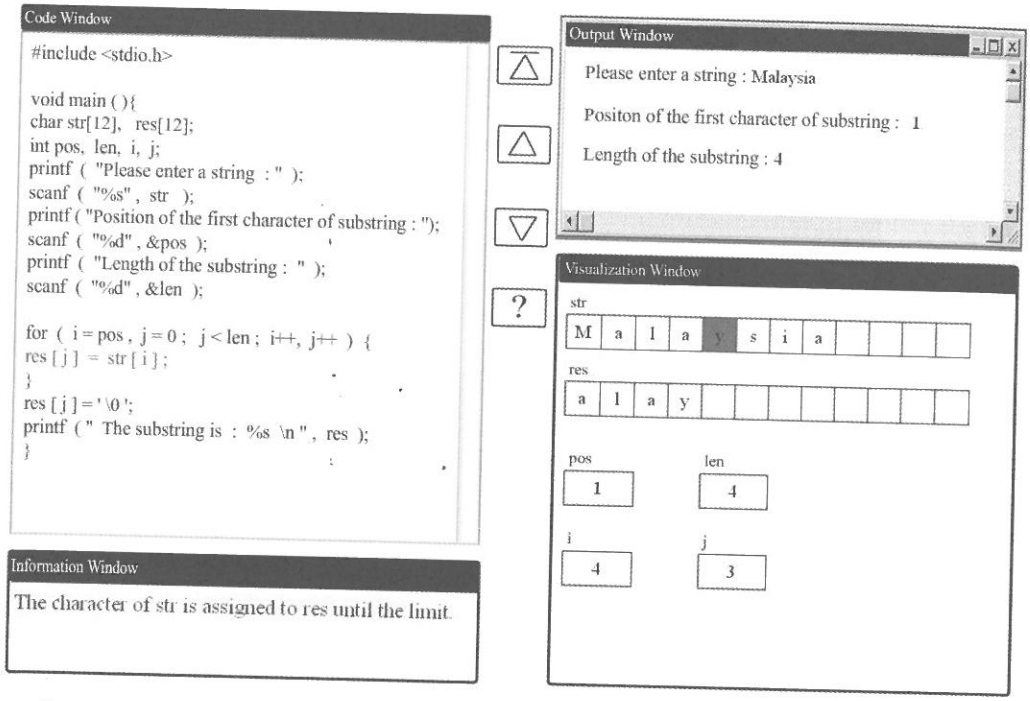

Fig. 2 Learning Object on Deriving Substring from a Given String

Primarily, LOs are developed separately by all four partner institutions, which are then disseminated to other partners. Comments coming from other partners, if any, are incorporated in the final development of LOs. The LOs developed so far covered topics including looping, conditional branching, array, string, function, and various topics related with data structures, algorithms, operating systems etc.

Survey on the Use of Learning Objects

The study was conducted in Shahjalal University of Science and Technology for Computer Engineering students who were majors of two programming courses. The course "Structured programming language" conducted in first semester using *C* language which typically covers the uses of selection logic, loops, arrays, functions, structures, and files. The course consists of lectures (2 hours/ week) and lab exercises (6 hours/week). Since the course was a first semester course, students do not have prior programming experience. To evaluate the performance of learning objects, 105 students (of Session: 2006) were grouped into two sections (Section A: 53 students and B: 52 students). Students having odd and even registration number were grouped into Section A and Section B, respectively. The same instructor taught in both the sections. The students of Section A are taught with the aid of LOs while the students of section B are delivered verbal lectures using traditional white board. The program visualization LOs were also available for the students of Section A when studying at home. The students found the aids interesting as learning tools. The final grades obtained by the students of Sections A and B are shown in Fig. 3. From the figure, it is clear that students using visual aids performed quite better than those without using the LOs. An important insight in the figure is that a big number (30) of Section B students (without using visual aids) got grades between 60-69 and 70-79, whereas 27 of the

Section A students got grades between 70-79 and 80-89. This shifting of grades illustrates a clea improvement of students' performance using LOs.

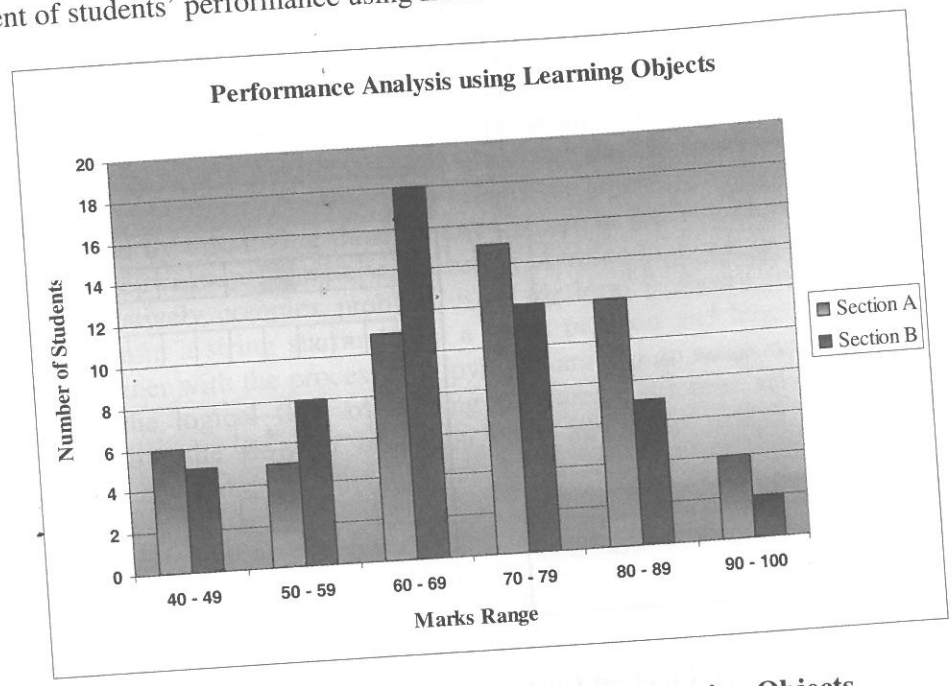

Fig. 3 Performance Analysis Using Learning Objects

Finally, students who were taught to use the visual aids (Section A) were asked some question on different aspects of the LOs, answers of which are summarized in Table 1. At the same time students of the previous session 2005 (those who learned through traditional approach) were allowed to use the LOs for practice and were then asked a different set of questions. The answers are summarized in Table 2. It is obvious that responses of the students in Tables 1 and 2 were completely consistent with the survey results presented in Fig. 3.

Conclusion

This paper has described the key issues of an effective e-Learning tool which is then followed by the presentation of learning objects developed in a collaborative environment. The aim was to help students improve their learning with the introduction of learning objects as part of an integrated learning situation. Evaluations have shown that students using the visualizing aids secure better grades than those who did not. The number of students in this survey is not very large; we are planning to repeat the evaluation process with a new group of students in the upcoming sessions.

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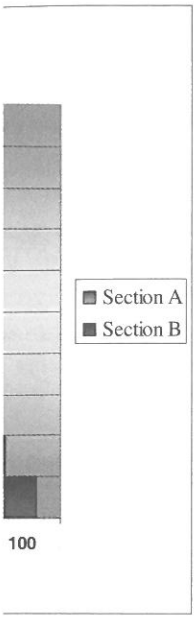

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Table 1 Response from the Students who are Taught Using LOs

Questions	Student %	Answers
1. In your opinion, what is the most beneficial aspect of the learning object?	47.2%	Step by Step Execution
	24.5%	Graphical Presentation
	22.6%	Interactive
	5.7%	Others
2. In which situations of programming you find the learning objects more beneficial?	52.8%	Looping structures
	22.7%	Selection logic
	22.7%	Uses of function
	1.8%	Others
3. What type of limitations the use of learning objects possess?	37.7%	System/Plug-in Dependency
	30.2%	Deficiency in the number of LOs
	28.3%	Multilingual Support
	3.8%	Others

Table 2 Response from the Students who are Taught earlier Using Traditional Approach

Questions	Choices	Score %
1. The use of learning objects in the classroom is better than the traditional approach using white board.	i. Agree	96.2%
	ii. Disagree	3.8%
2. Learning objects would have helped you understand the programming language better than the way you learned earlier?	i. Agree	88.7%
	ii. Neutral	7.5%
	iii. Disagree	3.8%
3. Exercising using the learning objects will increase your coding capability in laboratory	i. Agree	85.0%
	ii. Neutral	9.4%
	iii. Disagree	5.6%

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