Can Simulations Help Students Understand Programming Concepts: a Case Study

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Abstract

A simulation was developed to assist beginning students understand the mechanisms at work during procedure calls. The simulation (Kid Codie) provides the student with three program alternatives that demonstrate the way parameters are passed in Pascal programs. The software was developed for delivery to both on-campus and distance students.

Kid Codie was integrated into a degree subject for the first time in semester one 1995 and was included in the materials for distance students enrolling in semester two 1995.

Acceptance of the software by students was initially gauged by surveying on-campus students. Evaluation of usage by distance students will be undertaken during semester two, 1995. Student performance on the final examination will be evaluated to determine if use of the simulation had a significant influence on student understanding of the concepts. Examination performance in questions related to the simulation topics will be compared for the group of students who used the software, and the group of students who did not use the software and normalised against performance in other areas. These results will be presented at the conference.

This paper briefly outlines the design methodology and key software specifications. Details of the evaluation strategy and the results of that evaluation are presented.

Keywords

alternative teaching strategies, Pascal, procedures, parameters, evaluation, simulation

1. Introduction

The academic staff of the department of Mathematics and Computing at CQU believe that a number of concepts that are currently being taught in Computing 1A, an introductory programming unit, are not clearly understood by the majority of the student population. A major stumbling block in the unit is the understanding of procedures and functions. One week is spent on each topic in the fifth and sixth week of the course. Historically the second and third assignments test the student's knowledge of this area, hoping to pick up those students who are having difficulties. The main drawback of leaving the detection to this stage is lateness; by the time they receive feedback the students have advanced to more complex topics that build on procedures and functions.

To assist students in overcoming their difficulties with this topic, a Computer Aided Learning (CAL) simulation was developed. The aim was to develop a piece of educational software to simulate the passing of parameters to procedures. Graphical displays represent the values of parameters stored in memory as the user steps through the program. The execution of code correlates with the changing memory allocations. As variables are defined, chunks of memory are allocated and named accordingly. As the program manipulates the variables, the corresponding changes are reflected in the memory elements. This type of visual display allows the user to see the connection and relationship between the execution of statements and the physical manipulation of memory elements. The development of the software followed the systems development methodology described by Alessi and Trollip (1991).

The software was integrated into the learning resources to:

- provide motivational materials for the learner;
- illustrate difficult concepts by interactive experimentation and simulation.

The concept chosen, parameter passing, was one that experience has shown presented some difficulty to the majority of students in its current presentation style. Graphics and animation are used throughout the software to draw attention to particular concepts, to clarify and reinforce meaning and as a visual learning aid. Attention is maintained throughout the software by means of highlighting, graphics, animation and navigational interaction.

Units with stable content, that contain concepts that have proven difficult for students to learn using the print medium alone, and have large student numbers, lend themselves to computer enhancement. The use of technology expands the range of resources available in the learning environment so that potentially, students can learn more effectively.

Once the software had been developed, it was made available to students. In semester one, 1995 the software was demonstrated to the on-campus students and made available on a file server. In semester two, 1995 the software was also supplied to distance students.

A survey of on-campus student usage and opinion of the software was undertaken at end of semester one, 1995. An analysis of student performance in the examination, and the usage of the software by distance students will be undertaken at the end of semester two, 1995.

This paper describes the software, and the methodology and the results of the usage and opinion survey. A description of the methodology for the student performance analysis to be conducted in semester two, 1995 is also given.

2. Pedagogical concerns and principles

Oren *et al* (1990) describes the Guide metaphor where ‘a character is created and used by the author to link ideas and visual travel’. This software uses Kid Codie as the guide to link the concepts of parameter passing to the visual representation of dynamic memory. Kid Codie is a small animated figure that is used to draw attention to specific updates to screen information.

The main design and delivery constraints for the CAL application were the developer’s time, the delivery platform and the availability of developmental software.

When distance students enrol in programming subjects they are advised of a minimum machine configuration they will need to access, to complete their course. At design time, it was an IBM PC compatible with 1 MB RAM, hard disk drive of 20 MB, and EGA or VGA graphics capabilities. Any courseware developed for use by distance students must therefore adhere to this minimum configuration.

The use of technology as an educational tool has received significant support, with formal research studies identifying faster and more effective learning through the use of computers (Vinsonhaler and Bass, 1972) While research is vital to the successful implementation of any new learning resource, there is a move in the training sector from demanding technological innovation to seeking technological solutions for clearly identified learning problems.

Distance educators are generally cognisant of the potential learning gains that result when learning environments match students' preferred learning styles. Although individuals in a "class" of adult students may have different learning styles, they can and do utilise many different learning resources if these are made available to them (Verduin, Millar and Greer, 1986).

When designing the graphical interface of Kid Codie great consideration was given as to how we could represent memory locations accurately. Finally, it was considered more appropriate to represent memory in a simplified fashion to avoid the possibility of losing the students in the detail of the graphics and therefore not achieving the learning objective. The software is very easy to use, and only a very brief guide for students was required.

3. Presentation and Evaluation of the Simulation

3.1 Delivery

This package has been demonstrated in electronic blackboard form to the internal students of Computing 1A in the first semester of 1995. The lecturer of the subject used the simulation as part of a structured lecture on procedures. The lecture took the form of a brief overview of previous work, a programming exercise on procedures and the demonstration of the simulation package with a detailed walkthrough of options 1 and 3 (value parameters only, variable parameters only). The students reacted to the simulation with surprise and a little laughter. If one could gauge the success or acceptance of a package on the amount of laughter, then in this case the package was well received. After the initial amusement of a cowboy walking around the screen the students seemed to concentrate on the program message and the changing states of memory elements.

3.2 Usage and Opinion

A survey of students enrolled internally in Computing 1A, semester one, 1995 was undertaken in June. From a sample of forty-nine (49) students thirty-five (35) students were aware of the existence of the software. *Figure* 1 reports on where students viewed the software. It shows that very few students assessed the software individually as it formed part of the lecture materials and all those students attending the lecture were able to view it at that time.

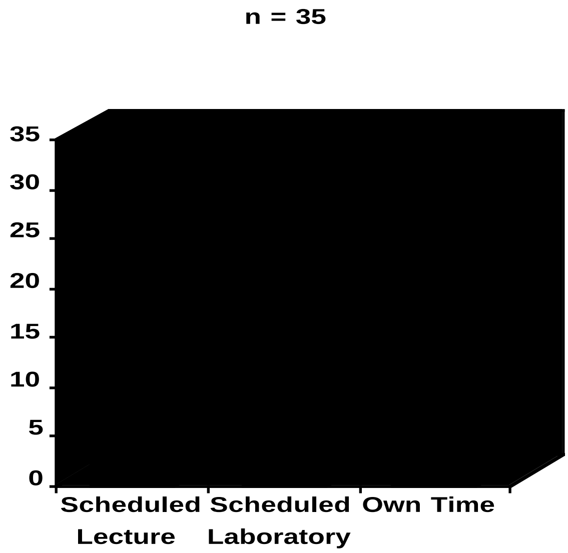

Figure 1. Where did you view Kid Codie?

Figures 2 to 5 were generated from five point questions, where responses from a rating of 1(Agree) to 5 (Disagree) were required. Figure 2 shows students' responses to the time saved in the lecture by using the software.

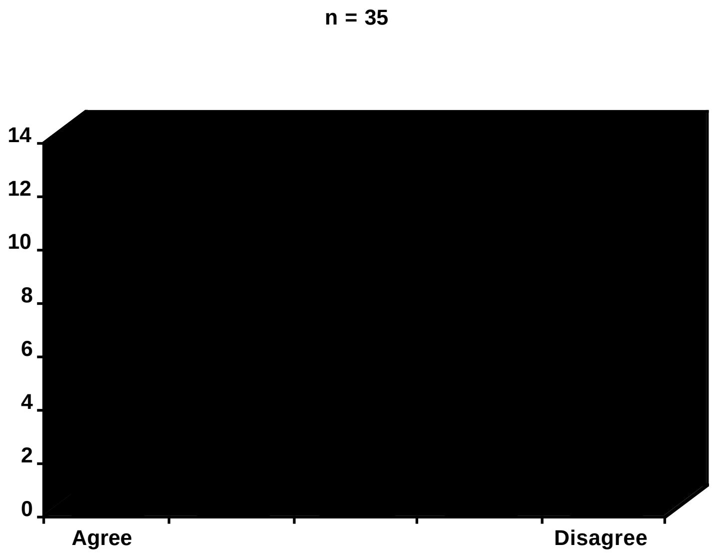

Figure 2. The Software saved lecture time as examples were shown quicker than doing them by hand

In the lecture situation, it is very difficult to show the actions that occur when procedures are called and parameters are passed without much chalk and dust flying. Having the software available, enabled the lecturer to explain concepts rather than making sure the diagrams were correct. An additional advantage for those students who wish to revise the process again was that they could gain access to the software and step through the process proceeding at their own pace after the class. Figure 2 indicates that the majority of students felt lecture time was saved by using the software.

Figure 3 shows how students perceived the usage of the software to make the lecture more interesting.

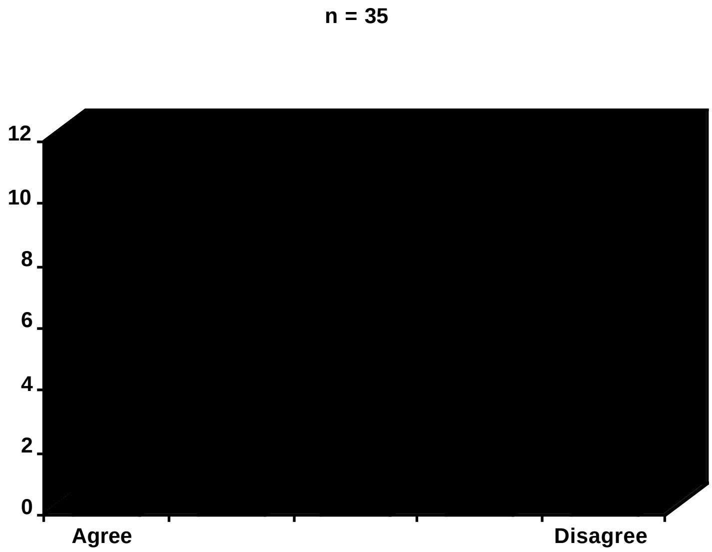

Figure 3. Made the lecture more interesting

By adding a different teaching and learning medium you are able to break up the transmission of knowledge into new and challenging ways. This often leads to greater concentration as a result of the changed environment. The majority of students felt that usage of the software did make the lecture more interesting. Whether students would recommend to others is shown in *Figure* 4.

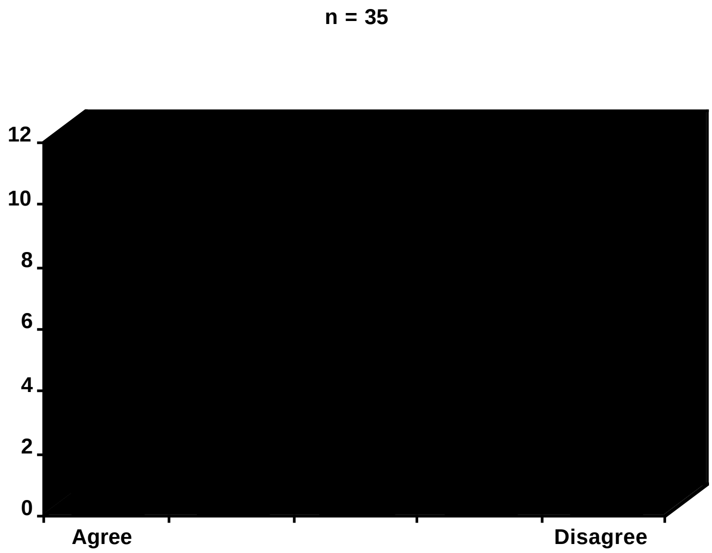

Figure 4. I would recommend other students view Kid Codie when learning about Procedures and Parameter passing?

The majority of students would recommend the software to other students.

Figure 5 shows student acceptance of software usage in lectures.

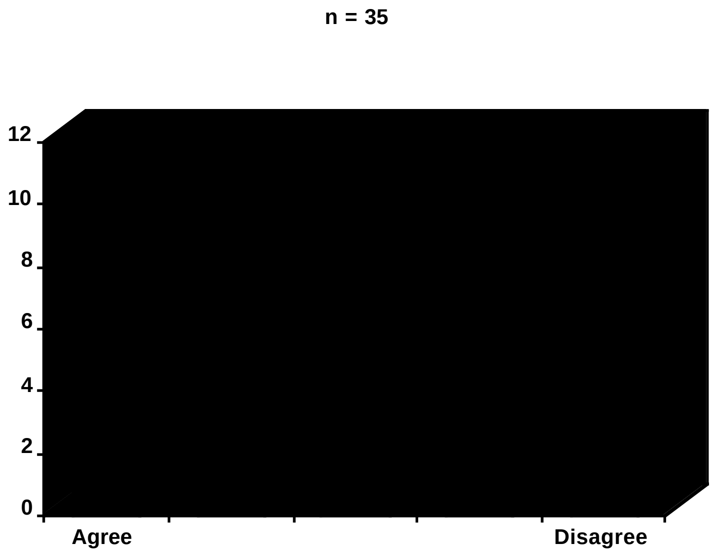

Figure 5. I would like to see appropriate software used for classroom demonstrations in other lectures.

In comparison with the results reported in *Figure* 2 to 4, a greater proportion of students would like to have greater usage of software demonstrations in lectures.

The students were then asked to indicate what they **liked** about using the computer for demonstrations in lectures. Up to 3 items could be listed, seventeen replies were received. These included:

- Easier to follow structured code;
- It was better than sitting here and just listening all the time;
- More interesting way to learn;
- Good visibility;
- Able to see practical example of work;
- Gave a clear and dynamic demonstration of Data Transfer in Procedures.

The students could also indicate what they **disliked** most about using the computer for demonstrations in lectures. Again up to 3 items could be listed with a total of 4 replies:

- Not too much detail;
- More complex questions preferred;
- Hard to see at times; and
- Slow graphic movement.

It should be noted that the survey took place nine weeks after the classroom demonstration and was distributed, collected and collated by an independent person. The authors are reasonably satisfied with the acceptance of the software. However, it is clear that lecturing staff must be more proactive in drawing students attention to the availability of supplementary learning resources.

4. Evaluation of Distance Students

An analysis of distance students' performance in Computing 1A, semester two, 1995 will be undertaken to try to determine if the software influences the understanding of procedures and parameter passing techniques. A specific question to determine student understanding of this topic has been included on the final examination. After students have completed the examination, a telephone survey of a random sample of distance students will be undertaken by an independent party. Interaction with the software and performance on the examination overall, and the specific parameter passing question will be analysed to determine if there is any significant correlation. The results of this analysis will be reported at the paper presentation.

5. Conclusion

The survey of acceptance by students of the use of the software in the lecture, although supportive, was not overwhelming. Reason for this result may be:

- that the timing of the survey was inappropriate;
- that a number of students did not have a difficulty with the parameter passing, therefore the software was of little educational value;
- that the traditional lecture method of teaching parameter passing is effective for a number of students.

It was satisfying to see that the students could see a wider application for this style of software and that the variety of teaching mechanisms may be helpful to achieve a fuller understanding in many topic areas. Whilst the software is intended for use by the on-campus students, it is felt that distance students, who do not benefit from face to face contact with tutors may find the CAL application of more educational value. It is hoped that the review of exam performance on parameter passing will provide more significant results.

6. References

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