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Learning Objects To Enhance Students' Conceptual Understanding Of Probability

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Introduction

This paper reports the quantitative findings from the development and evaluation of a series of learning objects (LOs) the design of which was based upon the results of a previously reported pilot study (Gossett, 2003). A series of five LOs were developed with the intention of clarifying students' conceptual understanding of the fundamental mathematical concepts that underpin the concept of probability. These LOs have the titles: 'fractions', 'decimals', 'percentages', 'pie charts' and 'probability'. The first three provide the opportunity for students to explore the topics interactively and hence, come to a deeper understanding of the underpinning concepts. The fourth LO, 'pie charts', was developed with the aim of integrating the mathematical concepts of fractions, decimals and percentages in such a way as to permit their interactive exploration outside the field of probability. In this way users obtain practice of manipulation and interconversion of the kind required when dealing with probability. The final LO, 'probability', provides an opportunity to use the knowledge gained from the preceding four LOs to investigate, calculate and express probability in a variety of forms.

Why learning objects?
The use of a suite of individual LOs, as opposed to a single computer simulation, was prompted by those data from the pilot study that indicated the computer simulation contained too much information to be effectively tackled in a single unit. By breaking down the components of the simulation into LOs, each concept can be presented in such a way that is likely to facilitate active learning more effectively (Boyle, 2003). The design of each LO contains overt constructivist elements that emphasise the importance of active learning and have the effect of placing the student at 'centre stage'. Here, learning is an active process in which learners construct new ideas or concepts based upon their current and past knowledge (Mills, 2002).

Interactivity and engagement were built into the design of the LOs through the inclusion of real-life examples and problems for the user to solve. Then, having produced a solution, feedback is available for both correct and incorrect answers. Also, users are able to design their own problems, develop solutions and hence gain ownership over the problem solving approach.

Methods

The London Metropolitan University participants taking part in this project were intermediate level students enrolled in the module 'Research Methods'. The cohort completed the evaluation as part of their introduction to research skills. The LOs were made available on-line and students were able to work at their own pace. When all the LOs had been used, the students completed a single questionnaire consisting of 36 items. They were also invited to complete an open-ended questionnaire with the request "Please describe your thoughts and feelings concerning the learning experience." The complete process took approximately one-hour.

Each item on the questionnaire was associated with a five-point Likert scale: SA, strongly agree; A, agree; U, undecided; D, disagree; and SD, strongly disagree. For negatively worded questions this scale was reversed when compiling data for statistical presentation.

Findings

The main objective of this evaluation was to provide data as evidence that the LOs were an improvement on the use of the computer simulation previously employed in the pilot study. The evaluation addressed three broad questions:

(i) Are the LOs perceived as being interactive?
(ii) Are the LOs perceived as being at an appropriate level? and
(iii) Do the LOs facilitate an understanding of the concept of probability?

Evaluation question (i): Are the LOs perceived as being interactive?

Seven items on the questionnaire related to this issue and their combined response totals are presented in Figure 1 below.

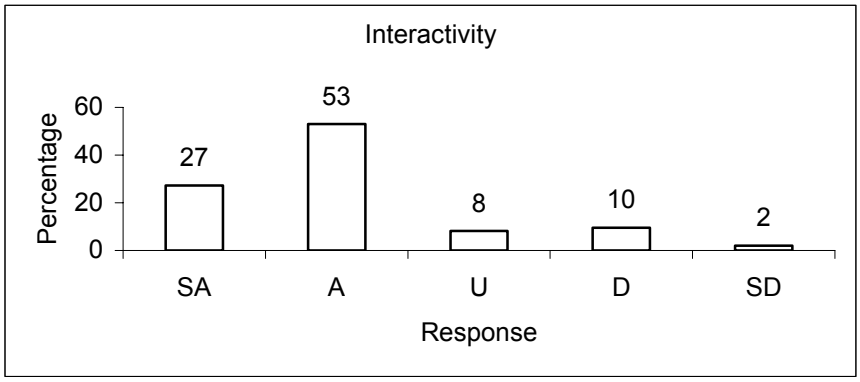

Figure 1. Frequency of responses to items related to interactivity expressed as a percentage of total responses.

Evaluation question (ii)

Are the LOs perceived as being at an appropriate level?

Seven items related to this issue and their combined responses are presented in Figure 2.

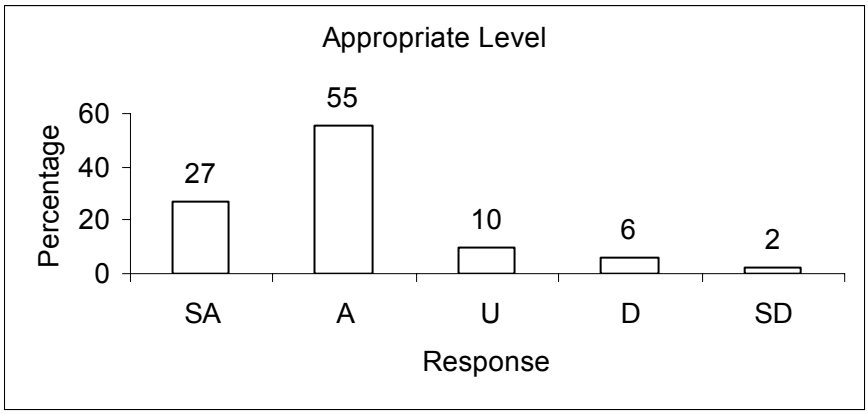

Figure 2. Frequency of responses to questions related to appropriateness of level expressed as a percentage of total responses.

Evaluation Question (iii) Do the LOs facilitate an understanding of the concept of probability?

Seven items related to this issue and their combined responses are presented in Figure 3.

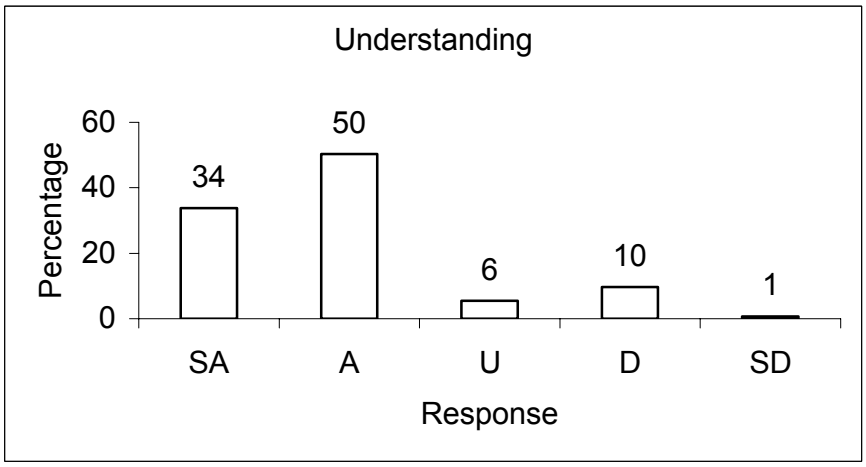

Figure 3. Frequency of responses to questions related to facilitation of understanding expressed as a percentage of total responses.

Discussion and conclusion

This discussion directly addresses each of the evaluation questions in turn and provides an overall conclusion and possible direction for future research.

Evaluation question (i): Are the LOs perceived as being interactive?

Figure 1 indicates that 80% of responses either agree or strongly agree that the LOs were interactive. Although these results do not provide an absolute measure of the level of interactivity or indicate that the level has reached a ceiling it is a finding supported by various student comments. For example, "Good interaction therefore made it fun to learn."

Evaluation question (ii) Are the LOs perceived as being at an appropriate level?

Each LO was designed such that following the introduction of a concept or idea the next page enabled the user to 'test their understanding' or apply their knowledge to problem solving. The intention was to give practitioners the maximum amount of practice in using the necessary mathematical skills coupled with the maximum amount of feedback possible. In so doing users were in a position to assess whether or not the LOs were pitched at an appropriate level for their intended purpose.

Those data, illustrated in Figure 2, indicate that 83% of respondents agree or strongly agree that the LOs are presented at an appropriate level. Further evidence to this effect is provided by comments from the student cohort: e.g. "The leaning experience was fun. It helped clarify some mathematical and statistical tasks that I wasn't too clear about before doing this test." As might be expected from the mixed educational background of the participating cohort, some reported that the level would be more suited to primary school or secondary school children. It is likely that these comments have come from students with more prior experience of mathematical concepts.

Evaluation Question (iii) Do the LOs facilitate an understanding of the concept of probability?

Figure 3 indicates that 84% of responses agree that the LOs have facilitated understanding of the concept of probability, although as with the degree of interactivity, considered in evaluation question (i), this is not an absolute measure of level of understanding. It indicates only that the participants feel their understanding of probability has been improved by use of the LOs. These results are supported by comments such as: "Easy to learn, explains everything well." and " Plenty of examples so you had clear understanding."

The main conclusions from the present study are that the majority (80%) of undergraduate students taking part in this evaluation had a perceived improvement of understanding of probability after using the LOs and that the LOs were interactive and pitched at an appropriate level. This result is broadly in line with the findings of Bradley and Boyle (2003) in their study of the use of LOs to support students of Java programming, namely: the majority of students (78%) reported that the animations within the LOs helped them to learn the concepts being addressed. However, it should be remembered that the culture and context of learning situations will always differ and therefore these findings can only conclude that certain features will have an influence on the behaviour and learning of students, but crucially will not be able to predict what that influence will be (Issroff and Scanlon, 2002).

The findings from this project will be incorporated into the next and final stage of development and evaluation. On the basis of these findings it is recommended that

the next evaluation be carried out on a larger scale across a wider range of level of University students, for example, across both Foundation year and Certificate level students. In this way further evidence will be gained as to the more general applicability of the LOs and to the effectiveness of the design features incorporated on the basis of findings from this study.

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