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Using a Computer Simulation to Enhance Students' Conceptual Development: a pilot study

Roger Gossett
Department of Health and Human Sciences
London Metropolitan University

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Introduction

Within Higher Education (HE) the ability to understand, interpret and evaluate quantitative research findings is an essential skill. Students need to understand how data are gathered and analysed, how results and findings are derived and how to analyse and critically evaluate their own research findings and those from the literature. In Sports studies, as in most disciplines, research methods and statistics are core components of undergraduate courses. Anecdotally, and from the author's own experience, modules with a perceived high level of mathematics content (e.g. research methods and biomechanics) are considered by students as difficult. This perception may, in part, be due to the varied mathematical background of the student intake, a contention supported by research (Crawford *et al*, 1998). Furthermore, earlier results by the same authors (1994) indicated that, "over 75% of students conceive of mathematics as a fragmented body of knowledge and learn it using repetitive and surface approaches". It is well documented (Biggs, 1979; Entwistle & Ramsden, 1983; Marton & Säljö, 1976) that students whose learning occurs through making abstractions or connections in order to derive meaning concerning reality are likely to adopt "deep" approaches to study, while students who conceive of learning in terms of discrete increases in the knowledge base are likely to adopt a "surface" approach.

The use of information technology as an aid to student learning has proponents both for and against (Abrami, 2001). What is not contended is that computer graphics are very effective in conveying an understanding of fundamental concepts through pictorial representations (Tijms, 1992). More recently it has been suggested that the microcomputer has the capability to enhance student understanding of abstract or difficult concepts (Hesterberg, 1998). In particular it is possible to create computer simulations of concepts in order to permit their visualisation by the student. Moreover, built into such exercises is the opportunity for students to learn by constructing their own ideas and knowledge from the computer simulation. In this way the simulation experience may benefit students by enabling them to develop their own understanding of abstract statistical concepts. Such an approach to learning development is underpinned by constructivist theory of learning (e.g. Bruner, 1966) which states that learning takes place when students are able to build on their pre-existing knowledge. To this end, any learning aid, such as a computer simulation, should ascertain the prior knowledge of the students and use it as a starting point upon which the more difficult concepts can be built. These principles have informed the pilot project, reported here, to develop an online interactive computer simulation (OICS) in order to aid students' learning of the concept of "probability".

The research

The OICS developed for this project was written using software entitled 'Flash' (Flash FX, 2000). Richard Haynes of the Teaching and Learning Technology Centre (TLTC), London Metropolitan University, completed the multimedia development, the prototype of which was trialled with students during this project. The 2002/03 cohort of second-year students enrolled onto the Research Methods module of the BSc in Sports Science (*N*=32) participated in this study. Participants were randomly divided into two groups (A and B) and completed a 15-minute test (Test 1) to determine their baseline level of ability in using the concepts to be developed in the lecture and OICS before any teaching. Next, each group alternately received lecture presentations and on-line teaching, followed by evaluative tests (2 and 3) and open-ended questionnaires.

Quantitative tests each contained 18 questions that were graded according to Bloom's taxonomy of learning objectives (Bloom *et al*., 1956). The grading levels corresponded to knowledge, comprehension, application, analysis, synthesis and evaluation. For the purpose of analysis, scores from the first three levels were combined as low-level outcomes and those of the final three levels as high-level outcomes.

The findings

Quantitative data

The key finding from the quantitative data was that there was no difference in improvement of learning between the two groups, as measured by scores on both the low-level and high-level outcomes. Test 1 results indicated that groups A and B started at approximately the same level of prior knowledge. With regard to the low-level outcomes, both groups significantly improved as a result of their first learning experience, i.e. either the lecture or the computer simulation exercise. But the change could not be related to mode of learning, because when each group then received the alternative learning experience, there was no further significant improvement in learning. In the case of the high-level outcomes neither group made any improvement in their test (1) scores after their first exposure to a learning experience. However, following their second, alternative learning experience, both groups showed a significant improvement to their test (2) scores.

These results suggest that for high-level outcomes, one learning experience in isolation, either the online resource or the lecture, was not sufficient to generate any improvement; learning in both modes was necessary. It is possible that those students who received the on-line resource before Test 3 (Group A) may have needed the opportunity to clarify their conceptions and reconstruct their misconceptions before learning took place. Students who received the lecture before Test 3 may have needed the opportunity to build their own meaning through significant interaction with the new information. In a recent review of the literature on using computer simulation methods to teach statistics (see Mills, 2002), no studies were identified for the teaching of "probability". However, in the teaching of the related topic of sampling distributions delMas *et al* (1999) reported similar findings, concluding that, "although computer simulation methods can enrich a student's learning experience, additional activities are required in order for students to change their misconceptions".

Other explanations of the increase in learning due to receiving alternate learning modes may be: more time was needed in order to allow the concepts to be clarified in the mind of the students, and repetition was all that was needed without change of mode.

Qualitative data

The open-ended questionnaires were used for three purposes: to identify issues of importance to the students that may be taken into account in the design of the software; to inform the development of an evaluative questionnaire for use in the proposed extended project (not reported on in this paper); and as a means of gaining feedback on the learning experiences of the students across both learning modes.

For the online resource, strongly represented views regarding the content of the software were: too basic, not possible to ask questions and insufficient time. Students also remarked that working at one's own pace is an advantage, as is repeating sections where needed. Future design will enable the software content to become more challenging and interactive, and more time could be allocated for students to use it. Positive statements along the lines of 'keeps attention' and 'fun/ interesting/ enjoyable' reinforce the idea that the OICS is capable of supporting the learning environment by meeting the need of learners – especially, perhaps, those with learning styles that are more in line with the activist/pragmatist classification of Honey and Mumford (1982).

Regarding students' feedback on the lecture, it is perhaps indicative of this method that 58% of their responses could be categorised as 'teacher-centred aspects' compared to the smaller percentage (31%) categorised as 'student-centred aspects'. Possibly this ratio is an index of the 'teacher-oriented' *versus* 'student-oriented' approach of the lecturer himself. The proportion of responses that favoured the lecture over the on-line learning was very slightly higher than those that preferred the reverse. However, whether this difference is significant is uncertain, as it could have been due to a number of additional factors that affected student perception, not least of which is the fact that the on-line learning resource was in an early stage of development and, hence, was not error free. Positive statements regarding delivery of the lecture accounted for 22% of responses, compared with 41% of responses associated with positive views of the on-line learning. This seems to indicate that, overall, students found the use of the on-line learning a worthwhile experience.

The quantitative finding (discussed above) that both modes of delivery were needed for students to improve their scores on the higher level objectives is supported by the fairly common theme (about 3% of all raw data) that 'delivery modes support each other', identified in the content analysis of students' own comments on both the on-line learning and the lectures.

Conclusion

The main finding of this pilot study was that the on-line intervention *per se* did not offer an improved instructional method over the more traditional lecture. However, employing an improved version of the computer simulation software may allow the teacher to assume more of a facilitator role, which, in turn, may enhance opportunities for students to discover and develop meaning and understanding as independent and active learners. A second, unexpected finding was that, in order to achieve significantly improved performance for higher-order outcomes, both instructional methods were necessary. This revelation points to the potential of "blended learning", combining online and conventional instruction, for increasing attainment of higher-level learning objectives.

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Biographical note

Roger Gossett is a senior lecturer in the Department of Health and Human Sciences. He has special research interests concerning all aspects of swimming performance in addition to learning and teaching. He is about to complete the second year of the MA in Learning and Teaching in HE (MALTHE). This project was completed for the module Applying Learning Technologies, part of MALTHE, and will form the basis of his final year dissertation.
[email: r.gossett@londonmet.ac.uk]