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Deus ex machina: studying archaeology by computer

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33.1. Introduction

The use of computers for studying archaeology has progressed little since a review was presented at the CAA conference five years ago (Martlew 1988b). Computing at that time was almost completely confined to the archaeological methods curriculum, as a technique in its own right. Low priority was given to developing computer-assisted learning (CAL) materials, and the emphasis of the few programs in existence lay towards numerical aspects such as ^{14}C dating and statistical analysis. The status of CAL in archaeology reflected the general attitude towards teaching in universities, with relatively few resources being made available in comparison to the resources allocated to the primary research function. Major developments in CAL in any sector of the education system have in fact depended not on individual institutions, but on centrally funded national programmes aimed at raising awareness and promoting development work.

In the decade from the early 1980s to the early 1990s, national initiatives have been aimed at the secondary and primary sectors, and archaeology has maintained a significant presence as a CAL topic despite rarely being taught as a separate subject. Universities offer by far the greatest opportunities for studying archaeology, including the practical skills for which no formal training programme currently exists. Any developments in university archaeology courses are therefore of major importance for the future of the discipline, both in academic terms and in practice. This sector has recently received national funding for CAL development, but the goals set by the funding agency have a significantly different emphasis from those of earlier programmes. This paper examines the implications of the change, and raises issues of concern to all who intend to teach or learn aspects of archaeology with the help of a computer.

33.2. National initiatives to support CAL developments

The Microelectronics Education Programme (MEP), launched in the early 1980s, recognised the dual role of computers in education as teaching machines as well as being a subject in themselves, and proposed "the dual aim of enriching the study of individual subjects and of familiarising pupils with the use of the microcomputer itself..." (Fothergill 1981, p. 1). Several programs relating to archaeology were produced in the new climate of software development for primary and secondary schools which MEP promoted. A common theme was to reproduce the excavation process in some way, usually with the computer revealing finds and features grid-square by grid-square. Stratification tended to be presented in terms of three or four overall levels or phases, and the range of sites included an Egyptian tomb, a Roman villa and an Iron Age hillfort. A second theme was developed on the adventure game approach, with Viking invaders or Norman castle-builders having to complete tasks and overcome obstacles set by the computer program in a historical context.

The first major initiative to be aimed at higher education was the Computers in Teaching Initiative (CTI), launched in the mid-1980s. Two archaeology projects were successful in attracting funding, the SyGraf excavation simulation package developed at Southampton and York , and the Leicester Interactive Videodisk project which explored the use of image databanks on a variety of archaeological topics. It is notable that the funding provided by both MEP and CTI was intended as "pump-priming" support to raise awareness and to get development work started. Having launched sophisticated projects such as SyGraf and the Leicester interactive videodisk, there was no intention to provide external support for continuing development work. Although CTI introduced many university lecturers to the possibilities of using computers for teaching, it did little to tackle long-term problems arising from the labour-intensive, and therefore expensive, nature of CAL software development. Furthermore, the funding was aimed at development, rather than delivery. It was left to individual institutions to assemble hardware for student use with funds obtained via different routes. A single initiative such as CTI was unlikely to raise the status of CAL in universities, diverting funds away from subject-based research towards general pedagogical applications. The prospects for continuing development on an institutional basis beyond the life of one-off initiatives were not good, and there was little expectation that CAL developments in archaeology would continue once the central funding had come to an end.

Perhaps in recognition of this, and in the context of wider changes in higher education, the Teaching and Learning Technology Programme (TLTP) has recently become the latest in the line of initiatives to support CAL at this level. Over the decade since MEP was launched the rationale behind national initiatives has acquired a new emphasis. While quality and enriching the learning experience still appear in the list of benefits of CAL, there is now much more interest in potential productivity gains. TLTP funding is intended primarily to improve productivity, but without sacrificing quality:

> "The aim of the programme is to make teaching and learning more productive and efficient by harnessing modern technology. This will help institutions to respond effectively to the current substantial growth in student numbers, and to promote and maintain the quality of their provision." (Universities Funding Council 1992, p. 1)

Qualitative educational evaluation is not mentioned at all in specific terms, while:

> "...productivity gains should be quantified, in terms of staff time released, additional teaching hours or student learning hours obtained, and through other suitable measures." (*ibid.*, p. 2)

The goal-posts have thus been positioned with respect to the most easily quantifiable aspects of CAL. It has proved in the past to be notoriously difficult to measure the effectiveness of educational software in pedagogical terms, since it is difficult to compare one teaching method directly with another under fully controlled conditions. Purely in productivity terms, a range of technological devices has been used over many years to increase student "throughput", from tape-slide machines to interactive Videodisks. Applications on a vast scale include basic training for US military personnel, and commercial training organisations are exploiting interactive multi-media applications based on CD and videodisk systems. Experience with these systems has shown that they do have advantages over other forms of teaching and learning, but they also have limitations. However, the true costs of software development and hardware investment are often hidden, but the need for subsidised development for the education market is clear.

33.3. Implications for CAL development in archaeology

There is considerable potential for using computers to improve *productivity* in studying archaeology, but the emphasis must remain at the same time on extending and improving learning opportunities. The approach to software development, however, is very different from that required by research computing. Consideration has to be given to the learning environment which is created by the physical setting of the computer and the way in which it is used, as well as by the CAL software which runs on it. As with any other teaching method, anything which causes distraction, dissatisfaction or irritation will act as a disincentive, and will prevent the student from learning efficiently. It is short-sighted to try to improve productivity without considering the total learning environment: a "battery farm" approach to studying archaeology by computer will be counter-productive. At the simplest and most obvious level, a greater emphasis on computer-based coursework will require a greater availability of computers than many institutions can currently provide, a problem which only adds to the growing concern over shortages in traditional resource areas such as libraries.

33.3.1. The learning environment

The scale of hardware provision is, however, only a more obvious aspect of a wider problem. If students are to be required to complete part of their assessed coursework on computers, attention should be given to the surroundings in which they are having to do the work. Poor lighting, reflections or glare from the screen, uncomfortable seating or inadequate space for documents and notes can make the computer-based learning experience an unpleasant one. Most institutions provide undergraduate computing facilities in "laboratories", the name deriving from the science laboratory in which apparatus is set out on benches so that students can perform experiments. Larger numbers of students can be accommodated simply by providing more sets of apparatus up to the maximum capacity of the laboratory. When translated into a computing laboratory, the physical constraints of this lay-out dictate one student per machine, and concentrate the focus of the learning activity totally onto the computer screen. This will be perfectly adequate when the computer is being used as a piece of scientific apparatus, by students learning programming, for example, or for simple levels of interaction such as multiple choice testing. However, to accept this as the only possible approach to studying archaeology by computer, because of the demands of productivity, is to sacrifice quality and the true potential of the computer as an aid to efficient learning.

33.3.2. The software learning environment

In addition to the setting in which computers are used, there are details of software design which can give rise to physical interference with the learning process. 8% of the male population and 0.4% of the female population have difficulty in distinguishing between colours, so care has to be taken when colour is being used for backgrounds and for highlighting. Computer screens, which employ transmitted rather than reflected light, bring additional problems, such as the unpleasant effect of using some reds and blues together (Pointeer 1985, p. 47). It is uncomfortable to have to read large amounts of text on a computer screen, and poor choice of colour can exacerbate this.

The highest quality graphics terminals are unlikely to be available for mass student use, so designers of CAL software have to take into account the level of detail which can be satisfactorily displayed using available equipment. This is particularly important when the subject matter might contain images of finely decorated artefacts, or of complicated excavation plans and sections. One of the first products of the archaeology TLTP Consortium was a short demonstration module showing the limitations of presenting scanned images on a computer screen: a balance has to be reached between screen resolution, image size on screen and in memory, and speed of display. The scanning process takes artwork prepared specifically for one medium — print on paper — and displays it using a very different medium. Although it is perfectly possible to achieve satisfactory results on a high resolution graphics screen, in the context of CAL tutorials it may prove difficult to work with published images which contain large amounts of fine detail, if they can not be broken down into sections. This, however, is only a problem if the software designer has decided that all the information in a tutorial must be presented via the computer screen. There may be no choice if the computers are packed into a laboratory with insufficient space to spread out journals and excavation reports, but the aim of using the computer should surely be to encourage and support access to archaeological information, not to exclude it.

Even when detailed images can be successfully presented on screen, the need to study them closely can lead to discomfort. Visual acuity — the ability to recognise detail — decreases with age. Mature students are beginning to make a significant contribution to the expanding university population, and may experience difficulty in reading poorly-designed computer screens. It is also less likely that mature students will have had previous computing experience, since for anyone in their thirties or older computers were rarely available during their school careers. The increasing emphasis on computers as teaching machines will create a new class of educationally disadvantaged, and provision will have to be made for the technophobic and the two-finger typists. There is, more seriously, a small group of people who suffer from photosensitive epilepsy, which could in some instances be triggered by a computer screen.

These considerations relate only to students' physical responses to having to work at a computer, but they are easily overlooked. It goes without saying that poor pedagogical design of CAL software will have a much more serious effect on the efficiency of the learning process. The proportions of students in the risk categories listed above may be small, but the overall increase in the student population means that a growing number of individuals may well experience difficulties when studying archaeology by computer. For a much larger number of students, learning efficiency can be impaired by relatively minor irritations which are too easily ignored in the drive to find a "high-tech" solution to the problem of increased student numbers.

33.3.3. Relevance to the archaeology curriculum

One of the most significant obstacles to learning is lack of motivation. A few archaeology undergraduates will be studying the subject because they are deeply interested in it, and perhaps wish to pursue it as a career. Most, though, will probably have chosen it out of ignorance, or a vague interest which owes more to Indiana Jones than to Colin Renfrew. These students in particular will quickly lose motivation if they perceive that their learning is being treated mechanically, or if they regard CAL as being introduced primarily to boost the income of the institution. A set of unconnected computer exercises, which have to be completed in order to gain a required number of academic credits, will do little to maintain or increase the motivation of the less committed student.

The trend so far has been for CAL applications in archaeology to deal with practical methods and techniques, and to avoid cultural and chronological aspects of the subject. This may in part reflect the nature of the funding, which has discouraged long-term commitment to areas in which changes in theory and interpretation may make tutorial packages obsolete. Lecturers may easily revise their own teaching notes in the light of a new discovery, for example, but few have the competence or the time to begin to re-write CAL software. This represents a general problem with CAL in archaeology: none of the "pump-priming" initiatives has allowed the establishment of a software production group, which will not only continue to create new and up-to-date materials, but will also retain expertise to support and maintain existing programs. It is clear from past experience that the education market is too small to support such activity commercially.

33.4. Approaches to CAL in archaeology

Since few students enter higher education having studied archaeology at school, there are many basic concepts and facts to which they need to be introduced. CAL would seem to offer an ideal solution to this problem, freeing academics to devote themselves to higher level teaching. This basic premise should be sufficient to satisfy the productivity demands of TLTP funding, particularly where students can be introduced to common materials and practical techniques before commencing laboratory work.

Computers can be used to support a variety of approaches to archaeology, at a range of different levels. At the lowest level, CAL packages can efficiently test basic knowledge and understanding through the use of simple student responses or multiple-choice questions. In many ways this is the easiest of the CAL approaches to implement, and the easiest to evaluate in quantitative terms. The danger in over-emphasising this approach, however, is that apart from being pedagogically limited it reinforces the students' view that the computer represents authority, and always knows the right answer. When using textbooks, students have to be encouraged to question the apparently immutable truths which they find in them, and this attitude is very easily transferred to the computer. The limitations of teaching machines quickly become apparent when progressing from simplistic testing of basic factual knowledge to assessing understanding of higher-level concepts. The greater the freedom with which the student can answer a question, the greater is the programming problem if the answer is to be marked by the computer. The temptation is to limit responses to simple alternatives which can easily be checked, as in multiple-choice questions. While this might fit in well with the "battery farm" approach of computer laboratories, it limits the level of learning activity which can take place. In order to develop the computer's potential for studying archaeology, it has to be seen as part of a range of resources rather than as a stand-alone teaching machine.

This approach is exemplified in problem-solving exercises, which encourage students to assess evidence and reach their own conclusions. It is less easy to implement, and to assess, than simple multiple-choice questions, but it has much greater potential for enriching the learning experience. The computer facilitates learning rather than controlling it, and may not even have "right" and "wrong" answers against which to assess the work of the student: there is no *deus ex machina.* This approach encourages students to be active participants with responsibility for their actions, rather than passive, uncritical recipients of pre-digested facts. The evaluation of results in this context is a high-level skill, which is best performed by human rather than mechanical agencies.

33.5. An archaeological application

An archaeological example of the problem-solving approach is already being used in secondary schools (Martlew 1989), and is being updated and upgraded with the help of TLTP funds for use by undergraduate archaeology students. The program introduces basic issues concerning development threats to archaeological sites, and the interpretation of the results of excavations in advance of development. It is intended to introduce archaeology, in an identifiable context, to first level undergraduates who may have no previous knowledge of the subject.

The problem presented to students is to give an assessment of the archaeological impact of a proposed gas pipeline in East Yorkshire, for which there are three alternative routes. The resources available to students reflect the resources available to practising archaeologists in tackling this very real problem. Students have to evaluate the evidence on sites affected by the pipeline, and make judgements as to the importance of each site within the region. They ultimately have to recommend one of the proposed routes, perhaps suggesting minor amendments, and they have to justify their decisions. The progress of work and all the decisions which have to be taken are in the control of the student, and are not influenced by the computer. There is no single right answer which is dispensed by the computer at the end of the exercise. Students have to justify their strategies, and assessment will reflect the competence of their arguments as well as the knowledge and understanding of the archaeological issues which they display: in the past some have gone for minimum destruction either by the pipeline or by excavation, while others have chosen a route which directly affects more sites in order to create opportunities for excavation.

A problem-based application such as this is open-ended, and will introduce students to many of the real-life issues of archaeology in a contemporary context. The central issue can lead on to a wide range of important concepts which any student of archaeology ought to understand. For example, a significant source of evidence is the Sites and Monuments Record. The roles of aerial photography, geophysical surveying and fieldwalking are introduced, and students appreciate the composition and limitations of an SMR database through using one. Further consideration leads on to factors affecting archaeological distribution maps, and the interpretation of regional distributions.

A second stage in the exercise introduces students to evidence from excavations of the sites along the pipeline route which they have recommended, bringing in the concepts of stratification, associations and assemblages. Unlike many of the existing CAL packages on archaeology at primary or secondary school level, there is no attempt to reproduce the actual process of excavation. Without very sophisticated programming and powerful hardware, this has often degenerated into an unrealistic "battleships" approach, with sites being dug out one grid-square at a time, and vertical stratification being simplified almost out of existence.

The end result of the pipeline exercise is a report, produced to publication standards, in which the general outline has been provided by the computer, but the conclusions and supporting arguments have been thought out by the student.

33.6. Conclusion

While a variety of approaches and subjects will emerge from the TLTP projects, the general issues raised in this paper are of relevance to them all. In particular, it is to be hoped that the projects will concentrate on raising the quality of the learning experience for archaeology students, in addition to meeting the demands from the sponsors for increased productivity.

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