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**Computer assisted learning in UK engineering degree programmes:
lessons learned from an extensive case study programme**

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Abstract

This paper gives a synopsis of an extensive programme of case studies on real uses of Computer Assisted Learning (CAL) materials within UK engineering degree programmes. The programme was conducted between 2000 and 2003 and followed a questionnaire-based survey looking at CAL use in the UK and in Australia. The synopsis reveals a number of key messages for academic tutors and authors including students' enthusiasm for notes, self-tests and features to aid visualisation. Publishers should also consider pricing and licensing arrangements suited to the individual user.

Cet article donne une synthèse exhaustive des études de cas concernant l'utilisation concrète des logiciels d'enseignement assisté par ordinateur (EAO) dans les études d'ingénieur au Royaume Uni. Ces études, conduites entre 2000 et 2003, sont basées sur l'analyse de questionnaires concernant l'utilisation de l'EAO au Royaume Uni et en Australie. La synthèse révèle un certain nombre de points clés destinés au corps enseignant et aux auteurs, dont notamment l'intérêt des étudiants pour les cours papiers, les exercices d'autoévaluation et les éléments d'aide à la visualisation. Les aspects liés aux coûts et aux droits d'auteurs devraient aussi être pris en compte par les éditeurs, afin de faciliter l'accès aux logiciels par les utilisateurs individuels.

Keywords: Computer Assisted Learning, Engineering, University Degree

1. Introduction

Computer Assisted Learning (CAL) material is now available at levels from pre-school to Higher Education degree programmes. In engineering degrees, where numeracy and computer literacy are pre-requisites for study, it is not uncommon to see examples of CAL activity. The UK Higher Education funding bodies, through the Teaching and Learning Technology Programme (TLTP), have invested over £45 million since August 1992, developing a culture of CAL material use within UK universities that has substantially influenced engineering degree programmes. The TLTP is not the only source of engineering CAL material; a substantial proportion is generated in-house, usually within commercial authoring shells, while commercial packages are also widely available and often valuable for both learning and industrial application. The Resource Database and SearchLT Engineering database available from the UK Higher Education Academy Engineering Subject Centre Resource Databases [1] list several hundred electronic resources available for teaching engineering and mathematics subjects.

While CAL material is widely available, its use is still far from commonplace. A number of reasons are typically put forward for this, including the ‘not-invented-here’ syndrome, entrenched scepticism of the benefits and the steep learning curve associated with implementing the most suitable materials. It was with respect to this latter issue that EASEIT-Eng (Evaluative and Advisory Support to Encourage Innovative Teaching in Engineering), a TLTP project, was established and the case studies reported in this paper were conducted as the major part of this project.

1.1 Case study programme

This paper is based on 60 case studies, conducted between 2000 and 2003, of CAL activities in engineering degree programmes. The case study reports formed the major part of an evaluation of each CAL implementation and the full reports, which include detailed descriptions of the context of each implementation, are available in the Higher Education Academy Engineering Subject Centre Resource Database [1]. The intention of this paper, however, is not to scrutinise at the level of the individual case studies but to analyse, at the macro level, the whole set of case studies to form a general profile of CAL activity including its perceived benefits and limitations. Most importantly, assimilation of the responses of academic staff and students will generate a unique body of evidence of value to academics proposing to use CAL material, to authors engaged in preparation of new materials and to publishers involved in the distribution of materials. While numerous questionnaire-based surveys have been published by government agencies and in the academic literature, this assimilation of a large and diverse set of case studies is, to the authors' knowledge, the only one of its kind to date.

Important comparisons will be drawn between the profile of the 60 case studies and the 82 responses given to the questionnaire based survey of the opinions of academic and learning technology coordinators reported previously [2] and referred to throughout this paper as the 'survey'. While the survey might be regarded as offering views of academics based on a mixture of activity and aspirations, the case study reports focus on genuine and substantial activity and provide first-hand opinion from students as well as academics. In addition, the case study reports represent a refinement of the ability to

identify academics fully engaged in CAL activity and to base conclusions solely on the experiences of this special group.

The 60 case studies were conducted across a full range of engineering disciplines in 27 different universities all over the UK, representing, to the authors' knowledge, the most extensive programme of case studies ever conducted on this subject. In the survey, the Mechanical, Electrical / Electronic and Civil Engineering departments had dominated in proportion to the dominance of these subjects within the sector and, within the case study programme, a similar picture emerged. It is the authors' view that the sample is wholly representative of CAL activity across the UK. If this point is accepted then the data shown in this paper serves to validate some of the conclusions drawn from analysis of the survey data [2]. At the same time, some important differences with the findings of earlier surveys, including the EASEIT-Eng project's own survey, can be highlighted and important new factors can be identified. The case studies also reveal significantly greater detail about modes of use, in particular, and these are drawn out in this paper.

1.2 Evaluation procedures

An in-depth analysis of the evaluation procedures is outside the scope of this paper but it will be helpful to outline the procedures briefly. The definition of evaluation criteria and procedures was a key aim of the project. Many sources [3-6] were drawn upon, including the expertise and experience of staff within the project. This led to evaluation criteria being organised into 6 major themes encompassing, in total, 15 'big questions' as shown in Table 1. It was always the intention that the resource required to conduct an

evaluation would be manageable from the perspective of the evaluator, tolerable from the perspective of the academic tutor delivering the material and sustainable in the sense that evaluations could continue to be performed beyond the life of the project within realistic funding constraints. Both the evaluation criteria and the procedures were developed with this ethos in mind. They do not, for example, suggest comparison might be made between exam performance of a traditionally taught group and that of a group taught with an alternative approach because the resource demands of such an approach would be excessive on all involved. This is not a major hurdle; every academic feels comfortable to make choices about course textbooks and other aspects of delivery without recourse to such deliberation. It is their judgement as an academic expert that enables the decisions and it was the aim of EASEIT-Eng to inform such judgement for decisions to be made about CAL materials.

[Insert Table 1 close to here]

A good starting point for understanding the evaluation procedures is to consider the mechanisms used to judge performance against the criteria. An evaluation is performed in two parts: a software review is conducted by a subject expert concentrating on issues that are not dependent on context while the major part of the evaluation, the case study, document the context of each implementation and examines aspects that are strongly influenced by context. Table 2 shows a small excerpt from the evaluation overview matrix, showing the ‘big questions’ and the mechanisms to be used for evaluation. The individual aspects are not themselves intended to be read as questions but were intended to promote development of the evaluation tools. These tools may be in the form of

questions or issues to be probed. The design of the tools must be in an appropriate form for interviews, questionnaires, observations, feedback sessions, or focus groups.

[Insert Table 2 close to here]

Software reviewers were given basic factual information provided by EASEIT-Eng (E-E) and they completed a standardised web questionnaire (Qu). Case studies were conducted using a combination of three elements:

- Structured interviews with the academic tutor both well in advance of conducting the case study (P-EQu) and at the time of conducting the case study (Int).
- Observations (Obs) of sessions in which software is used are made
- Feedback (F/b) gathered from students by questionnaire and focus group.

Typically one such combination of activities will take place during the later part of the module delivery but the exact programme for each case study, including the number of visits required, was always determined on an individual basis from discussion between the EASEIT-Eng evaluator and the lead academic. Once the case study report has been prepared, the evaluator and academic discuss any remaining issues (wrap-up) and general feedback can be taken.

In many cases it was felt that a particular issue could have been evaluated to some extent by several mechanisms. While wishing to be thorough in the evaluations, repeated evaluation of the same issue was not consistent with the principle of 'manageable, tolerable, sustainable'. In addition, certain mechanisms elicited more

objective information than others and priority was always given to the mechanisms generating user feedback.

2. Synopsis of case studies

2.1 Packages in use

In the survey, the software reported in use was divided into six categories:

- *TLTP material*
- *Commercial CAL material*
- *In-house CAL material*
- *Commercial shells* such as Question Mark and Blackboard
- *Office software* such as the Microsoft Office suite
- *Engineers' tools* such as MATLAB.

Table 3 compares the number of reported instances of use of each software type from the survey with those in the case study programme. In some cases, it was felt that the reported uses of office software in the survey fell outside what is normally categorised as CAL but it was difficult to be sure from the information provided and the data was retained. In the case study programme, attention was limited purely to CAL activity and so the office software category has been eliminated from the comparison.

[Insert Table 3 close to here]

Data for the case study programme in Table 3 has been calculated in two different ways. The first is straightforwardly based on the total number in each category while the second figure, in brackets, has eliminated 7 case studies concerning the TLTP software CALVisual (image archive for civil and building engineers). These case studies were conducted through a collaboration between the EASEIT-Eng and CALVisual projects during the development of the CALVisual image database. It is unlikely that so many case studies using this material would have been conducted without this collaboration. The bracketed figure might therefore be regarded as a better indicator of the use of different software types in steady state use. The Table shows a broad agreement between the profile of the earlier survey and that in the case study programme, confirming that the survey was indeed representative of software genuinely in use and building confidence that the survey responses, which were necessarily limited in detail, had been categorised appropriately on the whole.

Not surprisingly, the TLTP software, which is freely available and was prepared at significant cost specifically for use in Higher Education, proved the most popular software type in use. Of the 8 packages in the case study programme, the apparently most popular TLTP package was EDEC (electronic design) evaluated at five different institutions, followed by CALGroup (topics in Electrical, Electronic, Manufacturing and Mechanical Engineering) at three different institutions. In a survey by the Higher Education Funding Council for England (HEFCE) of the use of all TLTP materials [7], CALGroup and Mathwise (undergraduate mathematics) were the two packages of most direct interest to engineers appearing in the list of packages most frequently reported in use. Two case studies on Mathwise were performed, one within engineering and one in

mathematics, but this is fewer than might have been expected given its apparent popularity in the HEFCE survey. EDEC, Mathwise and CALGroup were also the most popular packages in the EASEIT-Eng survey.

A curious feature in the data from the survey was that institutions reporting use of a particular package had not, in most cases, been involved in the original project consortia. In the case study programme there was an even split between uses at institutions that had been part of the original project consortium and those that had not. This is noteworthy because it counters an anomaly in the survey data while at the same time suggesting that reservations about the suitability of material developed by others – the so-called ‘not-invented-here’ syndrome - are not holding back uptake within the community.

Use of in-house CAL material (based on web pages, assessment tools such as Questionmark and learning environments such as WebCT and Blackboard) into which academics, or someone acting on their behalf, have input their own content are almost as popular as use of pre-prepared TLTP material. This is remarkable considering the significant time involved in preparation. This point also appeared evident from the survey and might have reflected the aspirational nature of questionnaire responses but the case study programme indicates that it is an even more popular approach than first indicated in the survey.

For consistency, software from the case study programme has been categorised in Table 3 as commercial CAL in line with categorisation at the time of the original survey.

Software such as PSpice (electronic circuit design) and SPSS (Statistical Package for the Social Sciences) were therefore included in this category when a better appreciation at the time of the survey would have placed them in the engineers' tools category. Analysed in this way there is agreement with the original survey. Analysis more appropriately would have seen some re-distribution and the figures for both commercial CAL and the engineers' tools would both be around 15% from the case study programme.

2.2 Modes of use

The case studies showed CAL material use from undergraduate Year 1 through to MSc in the approximate ratio 4:2:1:1 for Year 1:Year 2:Years 3/4:MSc. For undergraduate use, these ratios are similar to those in the survey but use at MSc level appears more frequent than suggested by the survey. For CAL activities, the average class size was around 70 in undergraduate years 1 and 2 while, in undergraduate years 3 and 4 and at MSc level, the average class size was around 20.

Table 4 summarises the parts of the curriculum in which the evaluated software was used. In this Table, software has been re-categorised in line with remarks made over the categorisation in Table 3. The table shows the number, N, of instances of use in each category of software (TLTP material, commercial CAL etc.) and, within each category, the number of times there was a particular type of use (coursework, tutorial etc.) expressed as a percentage of N. Any one case study can cover any number of types of use, as appropriate. The table also shows total figures from all software categories. Full

data from the survey is included for comparison with that from the case study programme. Total figures from the case study programme have been used to rank the modes of use in order of overall popularity.

[Insert Table 4 close to here]

In analysing this data, it must be acknowledged that the questionnaire inherently encourages respondents to tick as many options as desired. No distinction is made between primary uses of the software and secondary uses where the respondent is simply suggesting that the software could be or might have been used in a certain way. Consequently, the case study programme offers a much refined view of the genuine and substantial modes of use of all the software types. Two manifestations of this are immediately apparent. Firstly, for the engineers' tools category, there is little correlation between the survey and case study data as the result of the inevitable inclusion of Computer Aided Engineering (CAE) activities in the survey data while the case study programme includes only genuine CAL activity. Secondly, the number of modes of use selected for an individual response in the survey was on average 50% higher than for an individual case study. As a result, the survey percentages are consistently higher than the case study percentages with the exception of distance / open and remedial use which will be dealt with now.

Distance / open learning use heads the table at an overall rate in excess of 1 in 2 reported instances but this figure reflects the frequency with which academics said that the software was also available for 'self-study'. There was only one genuine distance

learning use and there was also an instance where campus-based students openly resented having to use software in a distance learning mode. Difficulties encountered by students in gaining access to software and the lack of conviction expressed by case study academics raise questions over the intensity of any self-study actually undertaken. The corresponding survey figures were much lower in all categories. These figures should, however, be viewed in conjunction with the striking figures for remedial use. There was no suggestion at all from any of the case study academics that suitability for remedial work was part of their motivation to introduce the CAL software and there were no examples of exercises constructed around the CAL software for remedial purposes. Combining the figures for distance / open and remedial use from the survey broadly matches the figures for distance / open use from the case studies. It appears that the open availability of the CAL software, reported in 55% of the case studies, is the reality when the survey academics described software as available for remedial work.

Use for tutorial work, at a rate of around 1 in 2 case studies, was of an altogether more substantial nature and was popular across all software types. A common scenario was one in which the CAL material use was based around timetabled tutorial activity making full use of formative self-assessments in the package. Figures from the survey and the case study programme are broadly in agreement.

Use in lectures, for coursework and to support or replace practical activities is commonplace at rates around 1 in 5 of the case studies. The figure for lectures is inflated because all the TLTP material uses associated with lectures were for the image database created by the CALVisual project with whom EASEIT-Eng had a specific

agreement to conduct evaluations. Consequently, in steady state, a low figure for lecture use might be expected for TLTP materials as, indeed, appears for commercial CAL material. Use for coursework was predominantly based on in-house CAL material, presumably written with the coursework exercise specifically in mind, and on the engineers' tools, the nature of which makes them well suited to project work. Use of TLTP and commercial CAL material for coursework appears to have been exaggerated by the survey. The survey also exaggerates the use of TLTP and commercial CAL material in practical activity. This is likely to be the result of survey respondents selecting responses because the software content was relevant to the coursework or practical exercise rather than only when the software was used directly for the coursework exercise; secondary rather than primary uses, as defined above. The same issue appears for group work where use is infrequent and significantly less frequent than suggested by the survey. The presence of CAE activity in the survey data exaggerated the use of engineers' tools for practical activity but this software type was still understandably popular for this mode of use. Use for administrative purposes was low in the survey and zero from the case study programme.

Table 5 summarises the data examining how the software is used, showing some significant variance with the image created from the survey. The overall picture from the case study programme is of a rather more carefully planned set of implementations than was apparent from the survey. A similar or perhaps slightly lower rate of use as an additional resource is shown together with a much higher rate of use as a replacement resource, including several instances where the CAL implementation was as a key part of a whole new replacement taught module. Like the EASEIT-Eng survey, a 1999

Higher Education Funding Council for England (HEFCE) survey showed use as a replacement resource to be relatively unpopular [8] and, while this is more true for the TLTP material than any other software type, it is not really borne out by the data for all CAL material. Timetabled use was consistently high and approximately twice as likely than suggested by the survey. From academic opinions expressed in the survey, use in timetabled sessions appeared important in maintaining positive attitudes amongst the student users.

[Insert Table 5 close to here]

In the case studies, use as an additional resource was typically intended to assist in the delivery of elements of a module that had been problematic previously, perhaps difficult conceptually or difficult logistically - for example additional site visits may be needed. Use as a replacement resource generally had similar motivations but the academic had taken a step further than those whose use was as an additional resource. In several instances, this had been encouraged by institutional strategies to increase use of technology in teaching. Amongst the set of timetabled uses, two-thirds followed a pattern where the timetabled use, sometimes only an introductory session, was intended to act as a catalyst to promote students' use of the software in their own time. Use directly for (summative) assessment purposes was a little less frequent than suggested by the survey, in which the incentive of assessment had appeared important in maintaining positive attitudes amongst the student users, but the high figure for 'non-assessed' use emphasises the popularity of self-tests which were a feature of almost half the case studies. A sector-wide survey [9], focussing on Computer Assisted Assessment

(CAA) and conducted at a similar time to the EASEIT-Eng survey, found a pattern of use in which, of those reporting involvement in CAA, there was a 2:3 ratio between assessed (summative) use and tested but non-assessed (formative, self-assessment or diagnostic) use. The case study programme is generally in agreement with this figure for the in-house CAL category which includes the kind of assessment shells popular for CAA. Overall, the non-assessed uses are dominated by the TLTP and commercial CAL categories, while assessed uses are dominated by the in-house CAL and engineers' tools categories. Use for assessment does not imply use under examination conditions, of which there were no examples in the case studies.

The detail available from the case studies reveals a number of interesting aspects in academics' use of CAL materials. The TLTP and commercial CAL materials were used in a similar style - principally as an additional resource but significantly as a replacement, normally with timetabled elements and generally not directly for assessment. Such materials typically included short and simple self-tests at the end of each section and these were extremely popular. Use of in-house CAL material demonstrates how such material is often designed with very specific objectives in mind. In-house CAL was the most likely of any of the software types to be associated with a new teaching initiative. It was also the least likely to be timetabled not because of any lack of commitment to its use but because it was designed specifically to be used in this way and the very high use for assessment is evidence for this. Engineers' tools showed a further, distinct pattern of use in which the dominant application was as a replacement resource, where the power of computer aided engineering was employed to demonstrate important engineering principles or where mathematical software was used as an

alternative to traditional maths teaching. Timetabled use was found to be extremely important because of the learning curve associated with the software package and the need to ensure that attention is kept on the engineering or mathematical principles of interest rather than on using the software itself. The suitability of engineers' tools for coursework-type assignments is responsible for the high frequency of use for assessment.

A quite striking feature of the case studies was the extent of each CAL material implementation. Most TLTP and commercial CAL packages are very comprehensive in nature, structured as a complete programme of study sometimes across an extensive subject area, but the implementations were most likely to use only a very limited amount of the available material as a small part of the total module delivery. The materials were certainly not used as the core of a module delivery. There were several examples where students commented on the comprehensive nature of a package in negative tones, making the case for greater guidance to identify the most important elements. In-house CAL materials, which were less extensive but used in their entirety, were generally associated with more contact hours and made a more significant overall contribution to the module delivery but they still rarely constituted the major part of a module delivery. The same was true of the engineers' tools which were typically used for significant coursework activities but which, again, did not represent the major part of a module delivery. The importance of properly integrating the CAL element with other elements of the module delivery was recognised in many of the case studies.

3. Overall views

3.1 Academics

In the case studies, the views of academics were obtained through a structured interview in which a series of open-ended questions were posed. This differs from the survey which offered respondents the chance to select statements from a fixed list. Nonetheless, a comparison of overall views is possible and interesting. In the case studies, it is of course true that the views are inherently those of enthusiasts for this mode of delivery. As would be expected, the comments made were still balanced and objective.

The three most popular views expressed in the survey were that CAL material ‘aids the learning process’, ‘enables the sharing of materials’ and that it ‘promotes learning independence’. By far the most popular view, expressed in slightly over half the case study interviews, was that the use of CAL material improved the quality of the student experience. Academics spoke of increased motivation, improved performance and assistance in dealing with both weaker and stronger students within larger and more diverse groups. The next most popular views, each expressed by just over 1 in 6 academics interviewed, were that the use of CAL material was effective in helping students visualise important ideas and concepts and was a benefit in saving or making more efficient use of time. The latter comment was often made with respect to the use of self-test material incorporated within these software packages, concurring with the survey view of the benefit of sharing materials. Indeed, the most popular suggestion for how to improve the CAL materials in use was to increase the number of self-test questions available, including addition of some more difficult problems. It was difficult

to find genuine evidence of the promotion of learning independence. Academics regularly referred to 'self-study' use of the software but with no more conviction than might be encountered in suggesting to students that they use textbooks to read around their subject. Furthermore, 4 in 5 case studies reported use of the software based on timetabled sessions and there is some evidence that a certain minimum level of timetabled support is important to a successful implementation. The most significant concern expressed by academics, which did not emerge from the survey at all, is related to IT infrastructure. It was a point made most forcefully by students and will be covered in the next section.

Several academics commented on the issue of record keeping. Four listed it as a positive aspect of their software use and four listed it as a feature they wished to see added. This is not an overwhelming number but it merits a mention because of the importance attached today to monitoring student progress and encouraging them to work at a consistent pace and because incorporation of self-tests, as described in the next section, presents an excellent opportunity.

3.2 Students

The notoriously frank views of students were not obtained directly in the survey and so the case studies offer vital insight in this area. In almost every case study, the students enthusiastically embraced the use of CAL materials within their study programmes. At a general level, this relatively unfamiliar mode of delivery was a welcome diversion from the more traditional modes. The students gave their greatest praise to features for

visualisation, from the straightforward use of images and video through to the incorporation of animations and simulations. By contrast, text heavy materials were criticised as hard to read on screen and in one case as 'boring, boring, boring'. Self-assessment tests proved almost as popular as features for visualisation, especially where results were used only for formative purposes, and one academic described the students as finding these tests 'irresistible'. If the students' appetite for self-testing was capitalised upon by combination with record keeping features then valuable data could be provided to a module tutor.

The students' level of satisfaction with features for visualisation and self-assessment tests was matched in scale by their dissatisfaction with two different aspects. The first concerns access to the software, a problem also recognised by the academics. Students claimed overwhelmingly that it was not possible to gain access to University computing facilities at convenient times, facilities were either closed, too busy or booked. As a consequence they turned to their own PCs only to be thwarted by slow downloads or restrictions on server access or licensing. Computer ownership amongst engineering undergraduates is now so widespread, as is a general culture of file-sharing, that this appears to have been a particular frustration. In some case studies, software choice had been influenced by the availability of a free, downloadable demo version but, in many cases, licensing arrangements are directed towards purchase at the university level rather than the level of an individual student. The second significant concern was expressed by students with some force - they wanted *notes*. In some cases they wanted handouts during an electronic presentation on which to add notes and in others they

wanted, but were unable, to print summary notes and diagrams from the CAL material. One student even commented that use of CAL material left them with 'poor notes'.

4. Conclusions

The case study programme and the earlier survey broadly matched each other in terms of the range of software types in use and the profiles across different branches of engineering and across different years of study, although use at MSc level appeared more popular from the case studies. There are, however, some significant differences in the profile emerging from the case study programme compared to that from the survey. This can be attributed to the inherently aspirational nature of data gathered in a survey exercise while the case study programme has provided the opportunity to ensure that all data is gathered from genuine CAL implementations and enabled a much sharper focus on the primary uses of CAL materials. The availability of views obtained directly from students has also added an essential, new dimension to this work. This comprehensive case study assimilation provides much weightier evidence of current practice than has previously been available.

There is no real evidence of a 'not-invented-here' syndrome and consortium generated materials are just as likely to be in use at institutions outside the original consortium as they are at the partner institutions. Despite the availability of substantial free material or commercial materials that still save academic preparation time, the tendency for academics to generate their own materials is even greater than suggested in the original

survey. For modes of use, the profile emerging from the case study programme differs from that suggested by previous questionnaire-based surveys. It is certainly a profile in which implementations are rather more carefully planned. Greater use as a replacement resource is apparent but dedicated use for remedial work is virtually non-existent. A number of important lessons have been learned from the case studies. In particular, these include issues related to written notes, self tests and other interactivity, computer access and licensing, timetabled support, remedial use and the desire to integrate small CAL activities into a multi-faceted module delivery. These issues are summarised for the key players generating CAL materials below.

For academics: Students do like the use of CAL materials but they still want notes to take away. They want to be supported in their use of software especially when engineers' tools are used to demonstrate principles. Timetabled support can work well as a catalyst to encourage self-study using the software.

For authors: Students enjoy the variety in teaching methods made possible with CAL material. They want animations, simulations, images and videos but not text. Academics want software in small units with self-tests incorporated. Self-tests are very valuable and students are keen to try them but they must include some more difficult problems. There is no real appetite for material intended for remedial teaching use.

For publishers: Pricing and licenses need to be targeted at individual students who want the software to take home and use on their own PCs. University IT facilities are unlikely to be able to offer students the desired level of flexible access in the foreseeable future.

Software should be considered as an integrated part of a broad based Learning and Teaching product for example to supplement the kind of combination currently available such as text book, worked examples book and presentation material. A software-only product is unlikely to be successful. Demand will continue for shells or learning environments from which academics can deliver their own dedicated materials.

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References

- [1] The Higher Education Academy Engineering Subject Centre Resource Databases, <http://www.engsc.ac.uk/er/resources/> (accessed June 2005)
- [2] Rothberg, S.J., Lamb, F.M. and Wallace, A., Computer-based learning in engineering degree programmes: a survey at the end of the 20th century. *International Journal of Engineering Education*, 17(6), 2001, pp502-511.
- [3] TEEM (Teachers Evaluating Educational Multimedia) project: <http://www.teem.org.uk>. (accessed June 2005)
- [4] Squires, D., An heuristic approach to the evaluation of educational multimedia software”, in *Proceedings of CAL-97 Conference*, Exeter, UK, available at <http://www.media.uwe.ac.uk/masoud/cal-97/papers/squires.htm> (accessed June 2005)
- [5] Guidelines for the design of educational software, working group 5 of the Accredited Standards Committee Medical Devices 156, <http://www.dental.pitt.edu/informatics/edswstd/> (accessed June 2005)
- [6] NEEDS: A digital library for engineering education, <http://www.needs.org/needs/> (accessed June 2005)
- [7] Use of TLTP materials in UK higher education, HEFCE report 99/39

- [8] Communications and information technology materials for learning and teaching in UK higher and further education, HEFCE Report 99/60a.
- [9] McKenna, C., and Bull, J., The CAA centre national survey of computer assisted assessment, in Proceedings of ALT Conference, Bristol, 1999.

TABLES

Table 1: Major themes and ‘big questions’ guiding the development of evaluation procedures

Table 2: Excerpt from the evaluation overview matrix

Table 3: Categorisation of software in use as a percentage of total number of instances, N.

Table 4: In what part of the curriculum is the CAL material used? Mode of use as % of case studies in each software category. Square brackets show corresponding survey data [2].

Table 5: How do you use the package? Modes of use as % of instances reported in each software category. Square brackets show corresponding survey data [2].

Table 1: Major themes and ‘big questions’ guiding the development of evaluation procedures

	Theme	‘Big Question’
1	What is the institutional context of the implementation?	
2	What is the pedagogic context of the implementation?	
3	What are the important features of the mode of delivery of the CAL package?	
4	Evaluating the package	General identification of the product
		Is the material written in a third party authoring package?
		What technical considerations are associated with the CAL package?
		How does the CAL package rate on overall appeal?
		What subject matter is addressed by the CAL package?
		Is the written style acceptable?
		How do the surface features of the CAL package perform?
		Are assessment elements of the CAL package useful?
		Are administrative elements of the CAL package useful?
		Is documentation for the CAL package useful?
5	Looking back, what is your impression of the CAL package now?	
6	Is there any other information of use for the evaluation record?	

Table 2: Excerpt from the evaluation overview matrix

Aspect of Evaluation	Review		Case Study				
	E-E	Qu	P-EQu	Int	Obs	F/b	Wrap-up
4b: Evaluating the package: Is the material written in a third party authoring package?							
Is CAL package written in a third party authoring package e.g. Question Mark, Authorware, web-authoring? Which one?	✓						
Comment on authoring skill of author e.g. enthusiastic academic, professional technical author				✓			
Comment from author on ease with which CAL package was prepared inside chosen authoring package				✓			
4c: Evaluating the package: What technical considerations are associated with the CAL package?							
Delivery medium: web, CD-ROM etc.	✓						

Table 3: Categorisation of software in use as a percentage of total number of instances, N.

	1999 Survey (N=111)	2000-2003 Case Study Programme (N=60 (53))
<i>TLTP material</i>	35	39 (31)
<i>In-house CAL (including commercial shells)</i>	25	30 (33)
<i>Commercial CAL</i>	30	25 (28)
<i>Engineers' tools</i>	10	7 (7)

Table 4: In what part of the curriculum is the CAL material used? Mode of use as % of case studies in each software category. Square brackets show corresponding survey data [2].

	Total (all categories, case studies, N=60)	TLTP material (N=23)	Commercial CAL (N=8)	In-house CAL (N=18)	Engineers' tools (N=11)
Distance / open	55 [19]	57 [13]	50 [18]	56 [32]	55 [9]
Tutorials	45 [54]	48 [69]	38 [48]	44 [46]	46 [36]
Lectures	22 [32]	26 [18]	0 [27]	22 [28]	27 [45]
Coursework	20 [57]	9 [49]	13 [61]	28 [50]	36 [100]
Practicals	17 [37]	9 [41]	25 [42]	11 [21]	36 [64]
Group Work	7 [17]	4 [5]	13 [21]	11 [6]	0 [36]
Admin	0 [8]	0 [3]	0 [3]	0 [4]	0 [0]
Remedial	0 [31]	0 [54]	0 [33]	0 [21]	0 [0]

Table 5: How do you use the package? Modes of use as % of instances reported in each software category. Square brackets show corresponding survey data [2].

	Total (all categories, case studies, N=60)	TLTP material (N=23)	Commercial CAL (N=8)	In-house CAL (N=18)	Engineers' tools (N=11)
Additional Resource	53 [61]	70 [79]	63 [52]	50 [60]	18 [55]
Replacement Resource	45 [19]	30 [36]	38 [9]	44 [18]	81 [9]
Timetabled	78 [41]	82 [41]	88 [39]	62 [21]	90 [73]
Non-assessed	78 [37]	100 [44]	88 [36]	61 [36]	55 [45]
Assessed	22 [30]	0 [33]	12 [36]	39 [22]	45 [36]
Exam conditions	0 [3]	0 [0]	0 [9]	0 [7]	0 [0]

BIOGRAPHIES

Steve Rothberg is Head of the Wolfson School of Mechanical and Manufacturing Engineering and Professor of Vibration Engineering at Loughborough University. He has research interests in noise and vibration measurement and analysis, especially the development of laser transducers for vibration measurement. His active interest in CAL activity began in 1994 and he had a key role in the creation of the Engineering Education Centre at Loughborough. He was Co-Director of the TLTP3 project EASEIT-Eng.

Fiona Lamb is Associate Director of the Engineering Centre for Excellence in Teaching and Learning (engCETL) at Loughborough University. Her previous roles include Director of LTSN Engineering (now the Higher Education Academy Engineering Subject Centre), a national centre that provides subject-based support to promote quality learning and teaching in engineering education, and Manager of Loughborough's Engineering Education Centre. She was Co-Director of the EASEIT-Eng project and has been active in many nationally funded learning technology projects in the UK.

Liz Willis is Project Officer at the UK Higher Education Academy Engineering Subject Centre, providing support for the Centre's activities, including enquiry and information processing, supporting events, resource production and running the Centre's Teaching Awards. Prior to this position Liz was a Design and Technology teacher, teaching 11-19 year olds.