THE DEVELOPMENT OF MULTIMEDIA EVALUATION CRITERIA AND A PROGRAM OF EVALUATION FOR COMPUTER AIDED LEARNING

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ABSTRACT

This paper outlines the evaluation criteria and the approach taken by the Biomedical Multimedia Unit (BMU) to evaluate multimedia technologies being developed in the Faculty of Medicine, Dentistry and Health Sciences at the University of Melbourne. In recent years greater emphasis has been placed on computer based learning in the Faculty. As a result a systematic program of evaluation was developed to monitor the development and implementation of multimedia technologies across the Faculty. Theories of learning and instruction were reviewed and the common features of these models formed the basis for formative evaluation criteria. Evaluation criteria were developed in three domains: instructional and conceptual design, interface and graphic design and user attitudes and affect.

In terms of instructional and conceptual design, issues such as the importance of introductory objectives, navigation and orientation, interactivity, sequencing and the need for learning objectives to be consistent with the content of instruction were considered. The evaluation of graphic design was organised by the primary features of the interface such as colour, frames, text, types of media, animations and graphics. These features were evaluated more generally in terms of useability, consistency, clarity, structure (size and spacing), relevancy, usefulness and co-ordination. Features of the interface were also evaluated using criteria of 'best practice' which were formed on the basis of previous research in the area (e.g. Boyle, 1997; Hannafin & Peck, 1988; Kearsley, 1985; Oliver & Herrington, 1995; Stemler, 1997). The final domain of formative evaluation assessed users' attitudes and affect, both more generally and in relation to specific aspects of instructional and graphic design.

Once these criteria had been established a program of evaluation which aimed to foster a culture of evaluation in the Faculty was set up. Questionnaires were developed in each of the formative evaluation domains. These questionnaires were administered to those associated with the development of computer aided learning (CAL) modules and CAL module users. The cycle of evaluation was consistent with the CAL module development cycle proposed by the BMU. By adopting a systematic program of evaluation it was envisaged that more educationally effective CAL modules would be produced and developers would become aware of issues which need to be considered when developing CAL modules.

KEY WORDS

Evaluation, multimedia, computer aided learning, instructional design, graphic design, user attitudes.

1. INTRODUCTION

A number of developments in recent years have led to the need for a more formal approach to the evaluation of multimedia technologies within the Faculty of Medicine, Dentistry and Health Sciences at the University of Melbourne. First, consistent with the University wide push to develop multimedia teaching methods in higher education, more energy has been directed into developing multimedia education packages for courses offered across the Faculty. Second, as of semester one 1999, a new problem-based curriculum will be introduced for students completing a degree in Medicine at the University of Melbourne. A key feature of the new medical curriculum is the emphasis placed on computer based instruction which is consistent with a self-directed approach to teaching and learning. This self-directed approach will complement traditional lectures and practical sessions. Seventeen multimedia education projects were undertaken in 1998 by the Faculty, the majority of which will be used to develop computer aided learning (CAL) modules to support the new medical curriculum. In addition to these projects, 60 on-line problems of the week are to be developed for use across the first five semesters of the course.

In order to assist with the design and development of multimedia technologies, the Biomedical Multimedia Unit (BMU) was established in the Faculty. In addition to assisting with project management, conceptual design, graphic design and multimedia authoring, part of the BMU's role was to assist Faculty members with the evaluation of their multimedia projects. This paper reports on one aspect of this evaluation strategy and has two aims: to outline the formative evaluation criteria and to report on the program of formative evaluation undertaken by the Faculty. While the program of evaluation was primarily developed to provide formative evaluation of CAL modules, it will also be applied to Faculty web pages and on-line problems of the week.

2. CRITERIA FOR EVALUATION

Evaluation may be used for a variety of functions such as needs assessment, refining goals, improving products or programs or estimating costs (Reeves, 1993). The BMU is primarily concerned with the evaluation of multimedia education. This involves the systematic review of the content, design and instructional value and worth of computer aided learning packages. Evaluation has generally been conceptualised as either formative or summative. The aim of formative evaluation is the refinement and improvement of a program or package while the aim of summative evaluation is to determine the impact and outcomes of a particular program or package (Guba & Lincoln, 1981). Making judgements about 'value' and 'worth' is fundamental to the formative evaluation process (Guba & Lincoln, 1981). Given this, when CAL modules are being evaluated a judgement needs to be made about what constitutes an educationally effective CAL module. In order to make this type of judgement, researchers and evaluators need to determine criteria with which to judge CAL modules.

However, there were a number of difficulties associated with determining such criteria and applying them systematically in the current environment. The first difficulty was that many of the CAL modules which needed to be evaluated in the Faculty had different pedagogical underpinnings. For example, some of the CAL modules being developed were based on a problem-based learning framework. Others were more didactic in their approach. In addition, the various projects had different foci or aimed to provide different educational outcomes. For example, some projects aimed to develop students' clinical reasoning skills while others aimed to further students' understanding of particular medical principles or concepts. Both of these factors – varied theoretical underpinnings and varied educational outcomes – implied the adoption of different criteria of evaluation.

While it may be difficult to apply a generic and systematic program of evaluation across the Faculty, there were a number of reasons to pursue such an endeavour. First, there has been a dearth of systematic evaluation on computer aided learning. Reeves and Harmon (1994) argue "Systematic evaluation and research regarding instructional hypermedia systems have lagged far behind their development" (p. 474). Concerns about the lack of this type of evaluation and

research are augmented by the speed with which multimedia is being developed and implemented in higher education. Systematic evaluation is also crucial if we are to produce educationally effective CAL modules. Given that the development of CAL modules will be an ongoing pursuit in the Faculty, content experts and multimedia programmers and designers need some sort of guidance in this endeavour. An additional advantage of instituting a program of evaluation over a number of years is that it provides an opportunity to scrutinise and improve the evaluation process itself. Finally, given the sizeable shift towards multimedia education in the Faculty (and in the University), there is a fundamental need to evaluate this shift and its implications in terms of students' quality of education. A program of formative evaluation is the first step in this process.

There were sound reasons, therefore, to develop a systematic program of evaluation in the Faculty. Yet the difficulties inherent in employing a systematic evaluation across projects in the Faculty remained. In an attempt to circumvent these difficulties and to fulfil the aim of providing a systematic approach to evaluation in the Faculty, major theories of learning and instruction were reviewed. Cognitive approaches to learning and various models of instruction were reviewed in an attempt to find areas of commonality which may be used to form the basis of evaluation criteria.

2.1 THEORIES AND MODELS OF LEARNING AND INSTRUCTION

Some authors have made an explicit link between particular instructional or learning theories and the development of computer based learning, showing how a particular model of learning or instruction may provide guidelines for the development of multimedia educational packages (Gagne, 1985; Hannafin & Peck, 1988; Hannafin & Reiber, 1989a, 1989b; Herrington & Oliver, 1997; Overbaugh, 1994). Others (e.g. Schmidt, 1993) have left these implications unstated. Regardless of whether these implications were explicitly articulated or not, it is clear that guidelines for computer aided learning may be based on theoretical approaches to learning and instruction. Drawing on these theoretical approaches, a number of researchers defined criteria which may be used to evaluate computer based educational packages (Hannafin & Peck, 1988; Kearsley 1985; Reeves & Harmon, 1994; Schueckler & Shuell, 1989; Shuell & Schueckler, 1989).

Hannafin & Peck (1988) proposed a series of evaluation criteria based on their learning foundations for computer aided instruction. They presented four categories of evaluation: instructional, cosmetic, program and curriculum. Reeves and Harmon (1994) present a review of pedagogical issues relating to education and training and proposed 14 pedagogical dimensions and ten user interface dimensions to guide multimedia developers. Based on cognitive conceptions of learning and recent research on teaching, Shuell and Schueckler (1989) formulated a list of criteria which could be used to evaluate multimedia education packages.

These criteria have provided a much needed focus to CAL evaluation. The taxonomies of Hannafin and Peck (1988) and Reeves and Harmon (1994) especially, provide a major contribution to the ongoing design and development of CAL modules. There were, however, a number of difficulties with applying these evaluation frameworks in the Faculty. Hannafin and Peck's (1988) system is overly broad, covering areas which were not immediately appropriate for use in the Faculty (particularly the domains of program and curriculum evaluation). However, the 15 questions on instructional adequacy and the eight questions dealing with cosmetic adequacy were seminal in the development of the evaluation criteria outlined below.

Reeves and Harmon's (1994) dimensions provide a valuable tool for researchers in multimedia education as they alert developers to areas which may have been overlooked in the development of a CAL module. However, many scales have low face validity which may preclude their use with novice respondents. The scales are also non-directive and are purely descriptive. The evaluation scale proposed by Shuell and Schueckler (1989), on the other hand, is limited in its scope and specificity and does not account for aspects of CAL modules which need to be evaluated (particularly in terms of interface design).

The criteria formed to evaluate the development and design of CAL modules in the Faculty were based on theories of learning and instruction and evaluation criteria researchers have used in the past. Rather than restrict the evaluation to a particular approach or theoretical model, the primary and common features which emerged from a literature review were taken to form the criteria for the evaluation in the Faculty. This eclectic approach was necessary in order to cover the diverse characteristics associated with multimedia instruction and medical education. Thus, formative evaluation criteria were classified into three domains: Instructional and Conceptual Design, Interface and Graphic Design and User Attitudes and Affect. Criteria in each of these domains will be covered in more detail below.

2.2 INSTRUCTIONAL AND CONCEPTUAL DESIGN

The domain of Instructional and Conceptual Design is made up of five criteria: introductory objectives and directions, navigation and orientation, interactivity, sequencing, and consistency between learning objectives and content of instruction.

2.2.1 Introductory objectives and directions

This is regarded by Hannafin and Peck (1988) as one of the most important features of a CAL module and is consistent with Gagne's (1985) instructional event 'informing learners of objectives' and Overbaugh's (1994) dimension of 'orienting activities'. There seem to be two fundamental reasons for incorporating this criterion into CAL design. First, many learning and instructional theorists have argued that learning is best facilitated when new information is perceived or encountered in context with previously held knowledge (Ausubel, 1960; Ausubel & Fitzgerald, 1962; Hannafin & Peck, 1988; Overbaugh, 1994; Park & Hannafin, 1993; Schmidt, 1993). By providing introductory notes or background to the content area, recall of existing knowledge will be facilitated, thus increasing the potential for learning. It is also important to provide introductory directives so that it is clear to students what the goals of instruction are and what is expected of them as they traverse the program. Doing this reduces learner anxiety and allows learners to judge what are the relevant and important goals of instruction (Overbaugh, 1994).

2.2.2 Navigation and orientation

Herrington and Oliver (1997) say there are three purposes to navigation: (i) to allow the student to locate and access particular information (ii) to allow the student to purposely move between related information (iii) to allow students to establish their current position within the program. The navigation system is particularly important in complex CAL modules so that student confusion and disorientation are avoided (Stemler, 1997; Park & Hannafin, 1993). A consistent and clear navigation system is therefore seen as a crucial aspect of an effective CAL module. The way the navigation system is set up will be dependent to a certain extent on the structure of the program but navigation should usually allow students to 'exit', go 'forward', go 'back', go to the 'main menu' or 'help' and 'glossary' if required (Locatis, Letourneau & Banvard, 1989; Stemler, 1997).

2.2.3 Interactivity

The utilisation of interactivity has been touted by some authors as the raison d'etre of computer based learning. Thus, interactivity is seen as one of the most important aspects of a CAL module and refers to features of the CAL which actively involve or engage the learner. Najjar (1996) defines interactivity "as the mutual action between the learner, the learning system, and the learning material" (p. 131). Interactivity may take several forms such as formative assessment questions on material covered in the preceding part of the program, asking students to perform some manipulation of the interface or challenging students to form hypotheses or predictions based on the material they have encountered. It is important to acknowledge that the criterion of interactivity cannot be satisfied through basic point and click procedures or by simply allowing students to use a navigation bar to actively move through the package.

There are a number of advantages to promoting interactivity in CAL modules. Interactivity limits the chance of instruction proceeding while the learner is not concentrating (Hannafin & Peck, 1988). By using feedback questions, a popular method of promoting interactivity, retention of knowledge is enhanced and remediation of incorrect knowledge is addressed (Hannafin & Peck, 1988; Stemler, 1997). The use of feedback questions also allows developers to individualise instruction for the learner which instructional designers have argued facilitates learning (Hannafin & Peck, 1988). One of the most important reasons for promoting interactivity, however, is that it encourages deeper processing of learning material. Interactivity makes students reflect on the content of instruction thereby encouraging the integration of knowledge and the elaboration of new information with pre-existing knowledge. Thus, interactivity promotes deeper processing which results in greater comprehension and retention (Park & Hannafin, 1988; Stemler, 1997).

2.2.4 Sequencing

Sequencing refers to the flow of content and information in the multimedia package. The content of an instructional module should be cohesive and well structured and designers should attempt to minimise the amount of energy and effort students expend trying to make links between information. Distracting or irrelevant information should be removed and the most important information should be given prominence. Hannafin and Peck (1988) argue that "Lesson flow is critical to the ease with which learning will occur. Lessons that move logically and smoothly from frame to frame and from section to section will likely maintain learner attention effectively" (p. 303).

2.2.5 Consistency between learning objectives and content of instruction

This may seem like a simple or indeed obvious criterion but it is often forgotten in the rush to develop multimedia software. It is one of the more important criteria, especially given the overall goal of a CAL module is student learning. Hannafin and Peck (1988) and others (e.g. Price 1991) argue that too often multimedia developers do not assure congruence between learning objectives and instruction (and also congruence with assessment). This puts the onus back on the content experts to clearly articulate what the objectives of the module are and to create the content in line with these objectives. The role of the instructional designer in accurately capturing this information and representing it in the CAL module is also crucial. It is important not to simply state the objectives and then go about the design and development of a multimedia package with scant regard for the objectives which have been proposed. The learning objectives should frequently be used as criteria to evaluate the CAL module while it is being designed and developed.

2.3 Interface and Graphic Design

When determining the criteria for interface and graphic design a trade-off is often made between enlivening the interface and distracting the learner from the content of instruction or the task at hand. Overzealous use of media or some other component of the interface (say, colour) may simply confuse the learner. The criteria for the evaluation of the interface and graphic design were, like the criteria for instructional and conceptual design, predominantly drawn from the literature on learning and instructional theory, and to a lesser extent on principles of message design and graphic design. Evaluation criteria in this area were initially organised by the primary features of the interface; namely, colour, frames, text, types of media, and animations and graphics.

Each of these interface components was evaluated in two ways. First, six generic questions were applied (as appropriate) to each aspect of the interface. These questions covered the issues relating to useability, consistency, clarity, structure (size and spacing), relevancy, usefulness and co-ordination. Other than this more general evaluation of the interface, specific

principles of 'best practice' were determined for each component of interface on the basis of previous research. The degree to which particular CAL modules conformed to these notions of 'best practice' was evaluated.

Due to space restrictions, all the specifications of 'best practice' cannot be explained here. However, a number of examples follow. In relation to the use of colour it is generally accepted that dark fonts should be used on light backgrounds (Oliver & Herrington, 1995; Stemler, 1997). If frames are used, a limited amount of information should be presented within a particular frame and scrolling should be avoided (Hannafin & Peck, 1988; Kearsley, 1985). In terms of font use, serif fonts should be used for text and sans-serif fonts should be used for headings (Boyle, 1997; Oliver & Herrington, 1995). When various forms of media are used thought should be given to the integration of these media and the degree to which the use of media supports the learning objectives of the module or of a particular screen. These requirements reflect some of the criteria against which multimedia developers were asked to evaluate their package.

2.4 USER ATTITUDES AND AFFECT

The final domain of formative evaluation was labelled User Attitudes and Affect. The assessment of users' attitudes and affect has been one of the most common forms of evaluation completed in the past. While the assessment of attitudes and affect cannot be the only form of evaluation, researchers cannot omit it because it is important to know whether students find a particular CAL module enjoyable, interesting and relevant. Students' perceptions of learning module are critical to students' motivation to learn. If students have positive perceptions of a CAL module this should not only extend the amount of time students spend studying but, more importantly, it should promote engagement with the program and thus foster deeper processing of instructional content. This analysis is consistent with motivational approaches to instructional design such as Keller's (1983) ARCS model.

Like graphic and interface design, the evaluation of affect and attitudes may be completed at a more generalised level (assessing the program as a whole) or may be applied to elements of instructional design (say on the use of feedback or the amount of interactivity) or elements of graphic design (say on the use of animations or the layout of the text). A number of questions were formulated to determine user's perceptions of CAL modules at both a general and a specific level. These questions cover issues such as effectiveness, efficiency, usefulness, degree of interest, enjoyability, appeal, degree of user-friendliness, relevancy and degree of engagement.

3. IMPLEMENTATION OF THE PROGRAM OF EVALUATION

One of the primary aims of the BMU was to establish a structure within which effective and efficient evaluation of CAL modules in the Faculty could occur. The first requirement in establishing such a structure was to clearly articulate the criteria deemed to be important to computer based learning. These criteria have been set out above. The second requirement in this process was the establishment of a means through which evaluation could occur. Two questionnaires were initially developed to fulfil this purpose (Kennedy, 1998). Items in these questionnaires corresponded to the criteria in the evaluation domains of instructional and conceptual design and interface and graphic design. A template questionnaire was developed for the final evaluation domain (user attitudes and affect). This template questionnaire comprised many items from the questionnaires in the first two evaluation domains. A definitive questionnaire was not developed for this evaluation domain as it was thought that questionnaires would need to be tailored to particular CAL modules. The template, therefore, acted as a guide for multimedia developers and was a starting point for specific questionnaire development in the domain of user attitudes and affect.

In developing these questionnaires it was deemed important to evaluate modules from different perspectives. Conducting evaluation from different perspectives was thought to be necessary for two reasons. First, it seemed that some criteria could not be reliably evaluated by students while others could not be reliably reflected upon by content experts or CAL developers. For example, it is unlikely that a content expert, who has invested much time and effort in creating

a multimedia package, will indicate that the module contains a lot of distracting or irrelevant information. Similarly, it may be difficult for a student to judge how the structure and content of the module fulfilled its learning objectives. The second reason to evaluate CAL modules from a variety of perspectives was the advantage of highlighting any disparities which exist between the perceptions of CAL users and content experts or developers. For these reasons, two questionnaires were used in the first two domains of evaluation. One questionnaire was completed by a content expert, a developer or a designer associated with the CAL module; the other questionnaire was completed by a potential CAL module user.

The administration of questionnaires was consistent with the multimedia development cycle outlined by the BMU (Keppell, Elliott & Harris, 1998). Figure 1 represents the development cycle and the corresponding evaluation cycle for CAL modules including the individuals who act as evaluators. The three sets of questionnaires were distributed to those developing CAL modules in the Faculty in three stages. The questionnaire covering conceptual and instructional design was administered first, interface and graphic design was then assessed and finally user attitudes and affect were recorded. The administration of these questionnaires overlapped to a certain degree, depending on the stage that the package was at in the development cycle.

Figure 1: Development and Evaluation Cycle for CAL modules

From Figure 1 it is important to note that in addition to requiring Faculty staff to evaluate their own modules, an evaluator from the BMU also performed formative evaluations in the first two domains. The BMU's evaluator used the same evaluation criteria as those used across the Faculty. After evaluations had been completed in any particular domain, the expert evaluator and the relevant individuals associated with the development process came together to discuss their perceptions of the module and to formulate revisions, changes or possible amendments or improvements.

By adopting a systematic approach to evaluation, it was hoped that a "culture of evaluation" would be established among those working on multimedia technologies in the Faculty. This was seen as important given, as has been noted, the limited amount of CAL module evaluation being completed generally and the inability of evaluation to keep pace with multimedia developments. By a "culture of evaluation" it is meant that through the use of a 'self-help-type' questionnaire and the clear articulation of evaluation criteria, content experts and multimedia designers and developers will become familiar with what constitutes 'good' and 'poor' computer based instruction. For example, by evaluating their own module, content experts may become aware that some sort of introduction is important at the beginning of a CAL module or that a clear navigation system is instrumental to the effectiveness of the program. So while it is not expected that evaluation procedures will keep pace with multimedia development, there is a system in place which will encourage content experts and developers to consider pedagogical issues when creating their learning package.

Fostering a culture of evaluation through a systematic approach has two distinct advantages. First, such an approach provides a solid foundation for alternative evaluation methods. Using similar criteria to those already established, CAL developers and designers are encouraged to gather data on their CAL module through means other than questionnaires. Thus, methods such as focus groups, interviews and observational studies are all used in conjunction with questionnaires and expert evaluations. Second, fostering a culture of evaluation and applying a systematic approach may encourage multimedia developers to pay more attention to the pedagogical framework which underpins their CAL module. The program of evaluation should not be inconsistent with specific learning and instructional models given the proposed approach is a generalised one. Thus, the suggested evaluation program provides a base from which more detailed, theory specific evaluations can be performed.

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