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Evaluating Online Mathematics Resources: A practical approach for teachers

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This paper describes a teacher-friendly approach to evaluating online mathematics resources. The Alessi and Trollip (2001) evaluation form is recommended as an instrument for assessing the worthiness of online resources from an instructional design point of view. An exploration of nearly 250 mathematics education websites revealed the benefits and limitations associated with using such a checklist. These issues are discussed through screen snapshots of webpages available from the WWW. This exploration also revealed that online resources from professional organisations' websites seem to be better designed, organised, easy to search and more comprehensive than those from individuals' websites.

Introduction

Gradually, WWW based educational resources are making their way into the school mathematics curriculum (Handal & Herrington, 2003). Online resources are potentially useful compared to normal courseware because of their abundance, availability at no cost, platform free accessibility, and their wide-reaching accessibility. On the other hand, a major limitation of online resources is their lack of appropriate pedagogy, coupled with poor instructional design and layout. According to Alessi and Trollip (2001, p. 392): "The tendency for the Web to be used only for presentation of materials greatly restricts its instructional potential".

Little research has been done in the area of evaluating online mathematics education resources. As the WWW grows in influence and size there is a need to document the quality of these online resources and those aspects of their design that are inhibiting their implementation. This study reviews a number of online mathematics resources and discusses their drawbacks in terms of the existing literature on courseware evaluation. The instructional design elements embedded in Alessi and Trollip's (2001) evaluation form are used in this analysis.

Evaluating Courseware

How do we know that courseware is well-designed and pedagogically sound? There are at least two approaches in the evaluation of courseware. The first approach makes use of evaluation forms and checklists that assess mostly interface design, navigation and/or control features of a courseware as well as other intertwined pedagogical variables. These features are then compared against a set of ideal criteria appropriate from an instructional point of view. A number of evaluation forms and checklists have been designed in this way (e.g., Alessi and Trollip 1991; 2001; Reeves and Harmon, 1994; and Sharp; 1996). A second approach is to evaluate courseware with respect to learning outcomes and the quality of the interaction with the learner. This second type of evaluation is referred to as context-based evaluation since assessment is carried out as the resource is used by the learner in a specific learning environment (Hosie & Schibeci, 2001).

In either approach, a number of dimensions or criteria are identified for evaluation. Reeves and Harmon (1994) have characterised fourteen instructional dimensions of computer based instruction which include epistemology and pedagogical philosophy. Haugland and Wright (1997) developed the Haugland/Shade Developmental Software Evaluation Scale (www.childrenandcomputers.com) to evaluate software for children. Their scale is based on ten criteria, namely: (a) Age appropriateness, (b) child control, (c) clear instructions, (d) expanding complexity, (e) independence, (f) non-violence, (g) process orientation, (h) real world model, (i) technical features, and (j) transformations. The distinctive feature of this scale is the introduction of a developmental variable. According to the author, only one quarter of existing software can be considered appropriate for children (Haugland & Wright, 1997). In addition, Stubbs and Burham (1990) proposed five critical dimensions in the developing of electronic distance education systems. These dimensions include: (a) Time and place independence, (b) realism, (c) communication paths, (d) ease of use, and (e) speed or immediacy. Alessi and Trollip's (1991) quality review checklist focuses on interface design, navigation and user's control of the page and is based mainly on the following features: (a) language and grammar; (b) surface features; (c) questions and menus; (d) other issues of pedagogy; (e) invisible functions; (f) subject matter; and (g) off-line materials availability.

Checklists and evaluation forms have been criticized because of their focus on features that are external and easy to measure, not capturing the process of teaching and learning. Indeed, context-bound evaluation tools can actually cover a broader range of pedagogical issues because of the diversity of methodological tools used such as measurement of learning outcomes through tasks and assignments; conducting interviews with students and teachers, participant observation methods, collecting students' work samples, video-taping student's interaction, analysing students' responses, and administering attitudinal scales (Hosie & Schibeci, 2001; Reeves & Harmon, 1994).

Evaluation Checklists

Although, context-bound strategies are powerful tools in bringing about a whole picture of the effectiveness of a courseware, when it comes to evaluate a large quantity of educational material, such as the case of online resources, checklists do a faster job. This is particularly pertinent for teachers because of their job demands and constraints. Qualitative approaches require specialized training and a longer time to implement. Evaluation forms and checklists have been successfully used for a long time in the academic community for courseware evaluation and have informed research and the teaching community accordingly. These instruments are particular useful as 'screening' tests for new software, and are of most use at the point where a decision has to be made on which software to trial. The use of evaluation forms and checklists also decreases the subjectivity factor and provides teachers with structured assessment criteria without necessarily requiring knowledge about multimedia or educational technology. By using checklists, teachers can become aware of issues in designing and assessing educational software. This is particularly true for teachers who have been educated in environments where the only technology was the blackboard.

Alessi and Trollip's (2001) evaluation form builds on the framework of Alessi and Trollip's(1991) quality review checklist which addresses the evaluation of pedagogical features, interface design, navigation and user's control of an online resource. The checklist has been successfully used in other studies as a courseware assessment tool (Noijon, 1994; Rasegotsa, 1999) and for training mathematics and sciences teachers in evaluating courseware (Handal, Handal, & Herrington, 2003). It seems to be indispensable given the poor instructional design of a large amount of educational software available in the market (Schwier & Misanchuk, 1994; Shneiderman, 1998). Alessi and Trollip's (2001) evaluation form is organized in items related to: (a) Subject matter; (b) auxiliary information; (c) affective considerations; (d) interface; (e) navigation; (f) pedagogy; (g) invisible features; (h) robustness; and (i) supplementary materials.

Evaluating Websites

This section illustrates the categories used by Alessi and Trollip (2001) in their evaluation form as they apply to nearly 250 mathematics education websites. These categories were used to analyse the quality in design and layout of the online resources focusing specifically on interface design, navigation and user's control. Although the discussion is not comprehensive, it is useful as a framework for initial exploration and research. In addition, the organisation of these resources was examined in terms of corporate or individual management of the websites. The study also aimed to validate categories used in Alessi and Trollip's (2001) evaluation form.

Six of the nine categories of analysis in Alessi and Trollip's (2001) evaluation form are discussed below. The following three categories were not considered to be relevant: *Supplementary materials,* referring to the quality of the auxiliary printed material that accompanies courseware, do not constitute a requirement for online resources and was not considered. Likewise, *invisible functions* of the lesson are related to the keeping of performance records as well as to issues of security and accessibility. Both features are rarely used in online resources and therefore are not discussed here. *Robustness* refers to the capacity of the program to work in different computer environments. Internet applications are platform free, although some multimedia effects need specific plug-ins and some webpages are designed to work better in either of the two most popular WWW browsers, namely, *Internet Explorer* or *Netscape Navigator.*

Introduction

Presentation of goals and objectives can enhance the understanding and motivational appeal of the subject matter and should be clearly stated and worded at the student's lexical level. Information must be relevant, accurate and complete. Table of contents, indexes and directions must be clear and information must be accurate and related to the curriculum. The screen in Figure 1 provides students with ample information about the task.

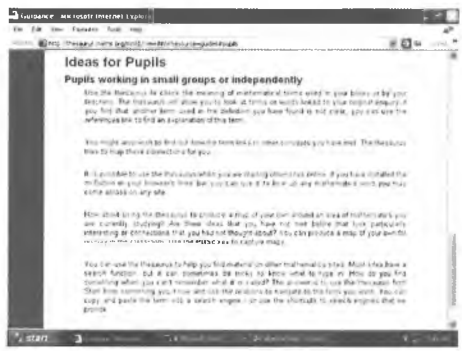

Figure 1

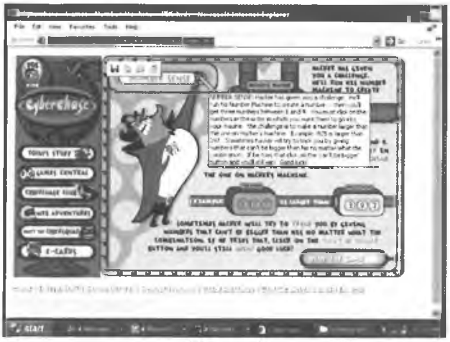

Figure 2

Displays

It is necessary to check whether (a) displays are uncluttered, (b) overwriting is avoided, and (c) attention is maintained to relevant information. In terms of presentation, it is also important to review whether texts, graphics, colour and sound are used appropriately. Fig. 2 shows a cluttered screen.

Motivation

A webpage should maintain the user's interest and must challenge the user across different displays. Visual momentum influences the learner's ability to extract and absorb content that is relevant to him/her across successive displays. Features such as zoom, sound or animation must be assembled in unity and consistent. Figure 3 shows a webpage with a dynamic percentage bar.

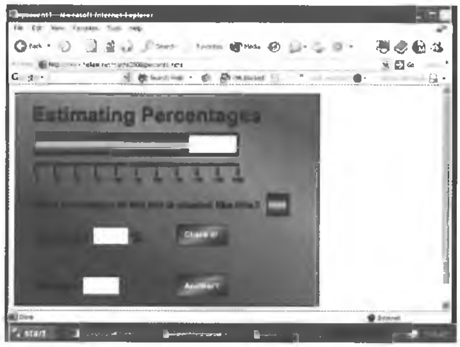

Figure 3

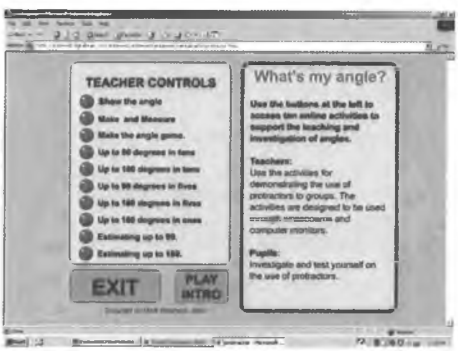

Figure 4

Navigation Aids

Tools availability should be checked to see whether the tools are active, or if they are present but are not active. Some tools should be removed or hidden from certain places. Otherwise, users get confused into thinking that the webpage is not working properly. For example, the control panel of a webpage might not be active in some sections. Most WWW browsers have sufficient navigational capabilities. Figure 4 shows an easy-to-follow tool board for selection.

Questions
Questions should be relevant and be presented in a variety of formats. Likewise, the webpage must facilitate learner's answering by giving clear choices and the possibility of more than one try. Feedback must be relevant and supportive. Questions should be economical with instructions on answering questions. The activity on Figure 5 shows an activity linking numerical, graphical and symbolic data.

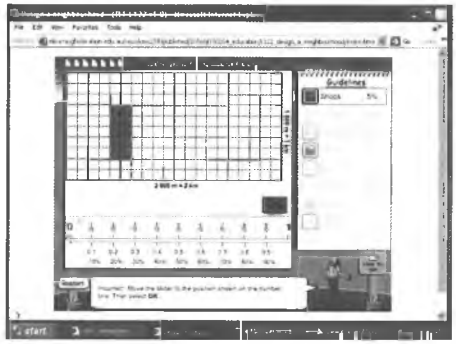

Figure 5

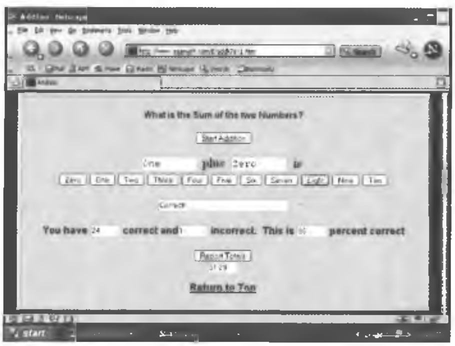

Figure 6

Format of Feedback
Self-evaluation can be achieved by giving the users a sense of accomplishment through acknowledgement or visual cues that indicate their progress. Self-evaluation can be achieved through self-tests or quizzes, using Yes or No questions, multiple choices, comment on results in simulation activity, among others. The activity in Fig. 6 provides continuous feedback on the task.

Content Structure
Menus should orient, give the opportunity of making a choice, and also of amending an incorrect choice. A dynamic menu is shown on Figure 7.

Figure 7

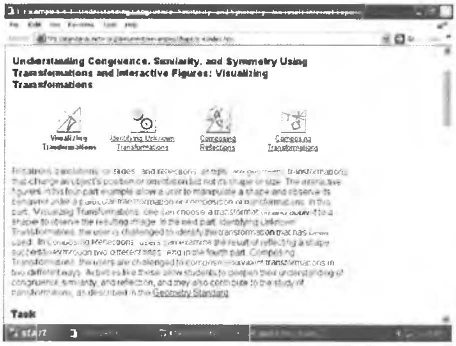

Figure 8

Directions

Advance organizers assist learners in finding information. Providing the user with an overview of the topics to be covered and how to access them through hyperlinks in maps or menus is a good start for any webpage. A consistent method of using this information should be presented to the learner in the earlier stages with a on-screen reminder such as *instructions.* The screen on Figure 8 provides overview information about a webpage on symmetry.

Learning Metaphor

The presentation of the information should be followed up by students' activity, as students will be more motivated if they participate actively with the webpage. Also, learning experiences, when sequenced, must follow a specific theme or topic. The learning experience in Figure 9 relates to a collection of activities based on the number line bounce.

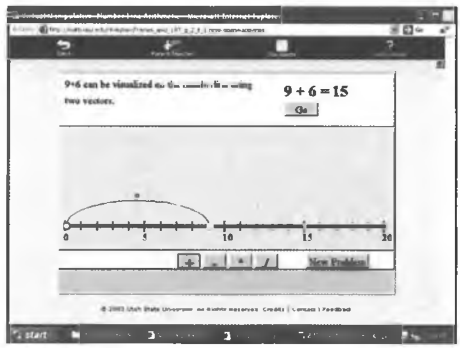

Figure 9

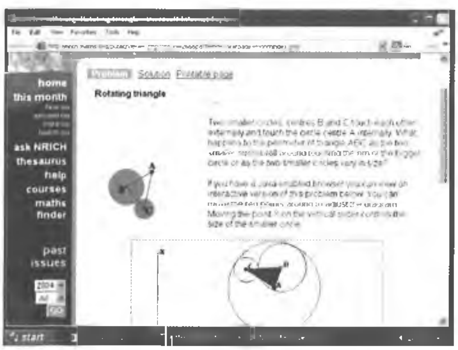

Figure 10

Methodologies

Student's interaction with the webpage should be more proactive than reactive. A proactive interaction emphasizes learner construction and generative activity whereas a reactive interaction is an answer to presented stimuli or to a given question. Interaction must be frequent and in a variety of forms. In Figure 10 students are required to draw geometrical generalisations from manipulating objects.

Format of Feedback

Appropriate webpages must consider the student's awareness of his/her progress in the learning activity. A webpage should be organised in such a way that the amount of information does not overwhelm the user. Users should also know how the steps chosen are completed so that they can progress. The tutorial in Figure 11 provides step-by-step solutions for each problem.

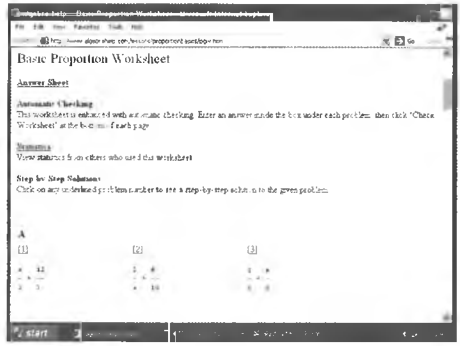

Figure 11

User Control

Control of the lesson is defined by the degree of command held by the learner over the webpage. Control includes navigation of the webpage, skipping the lesson, moving forward and backward and other interactions with the webpage. Likewise more control could be given for higher order thinking tasks such as problem solving and investigations in contrast to repetitive tasks. The webpage on Figure 12 allows users to choose the transformation they want to pursue.

Figure 12

Language, Style and Grammar

Language and grammar should be at the appropriate reading level, technical term and jargon, spelling, grammar and punctuation. Figure 13 shows a high lexical density text.

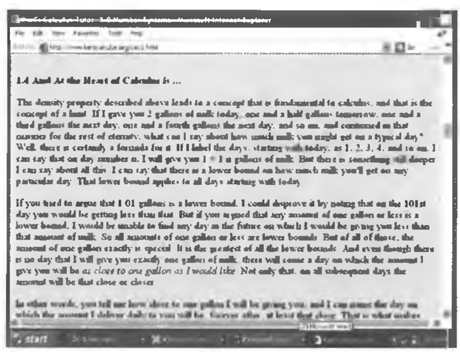
Figure 13

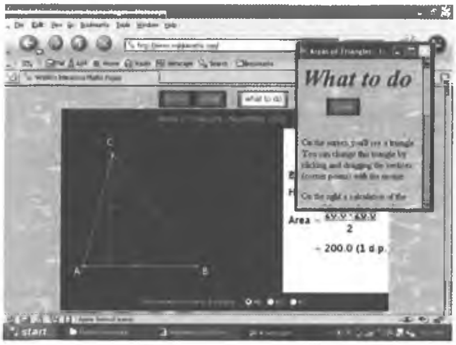

Figure 14

Help

A *Help* function may be available for each task so that the learner has continuos guidance through the learning sequence as shown in Figure 14.

Conclusions and Recommendations

This paper dealt with issues associated with the interface design, navigation and user's control of an online resource. It indicates how evaluation forms and checklists can be practical tools for teachers to identify positive and negative design features of an online resource. The discussion also showed, in general terms, that the Alessi and Trollip's (1991; 2001) framework can provide teachers with a simple and at the same time meaningful structure to assess WWW-based resources. These abundant resources require professional judgment in their selection and articulation into the school mathematics curriculum.

During the exploration of the 250 mathematics education websites, some limitations were observed when applying the Alessi and Trollip (2001) checklist. These limitations highlighted essential differences in design and usability issues between online resources and normal courseware. Not all the courseware design features are applicable to online resources for several functional and usability reasons. First, there is a diversity of online resource formats, namely: drills, tutorials, games, simulations, hypermedia-based materials and tools and open ended learning environments (Handal & Herrington, 2003). For example, drill and practice exercises do not provide complete feedback to the users, that is, a complete worked example. Contrary to many games applications, most tutorials do not necessarily require the use of multimedia effects. Tools and open ended learning environments are not formatted in terms of questions and answers but require exploration and investigation (Alessi & Trollip, 2001). Secondly, online resources differ from normal courseware in that the former do not come accompanied by manual or printed instructions on how to teach with the resource. This omission makes it difficult to evaluate the online resource in relation to an overarching set of pedagogical goals, outcomes or objectives. In other cases, some online simulations and games require the downloading of plug-ins from the WWW. This often makes the application unreliable as well as more difficult for the assessing teacher to run and evaluate. Finally, many online resources are embedded on webpages that are not consistent with other pages of the same website. As opposed to normal courseware, the organisation and sequencing of online learning activities are not well articulated and goal-oriented making it difficult for teachers to choose especially when they are searching for activities supporting a specific curricular topic.

Generally speaking, it was found that online resources created by professional organisations and organized in inclusive websites such as the Learning Federation (http://www.thelearningfederation.edu.au), Cambridge University (http://www.nrich.maths.org), the National Council of teachers of Mathematics (http://illuminations.nctm.org/imath), York University (http://www.counton.org) or the Shodor Foundation (http://www.shodor.org), have a better instructional design than those created by individuals. These are comprehensive websites whose online resources are more interactive, pedagogical oriented, sorted by grade level and curriculum objectives, thereby constituting a better search strategy for practicing teachers. Additionally, their URLs are also easier to remember! On the other hand, it is estimated that there are 500 individuals' websites, a figure that certainly reflects the growing enthusiasm and commitment of the mathematics education community to produce and share resources using the WWW medium. Eventually some sort of centralised database of online resources by curriculum objective, grade level and/or type of application sought should be designed to facilitate teachers' identification and access to the enormous amount and variety of online resources.

More research is certainly needed to modify courseware evaluation instruments to the nature of online resources. Research is also needed to investigate the process of developing and supporting evaluation skills for practicing school teachers to facilitate the application of these worldwide resources in the mathematics classroom.

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