Evaluating online mathematics resources

A practical approach for teachers

BORIS HANDAL, **PARVIN HANDAL** and **TONY HERRINGTON** report on the development of evaluation criteria for online resources and provide practical information about some key websites.

Gradually Internet-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".

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 courseware as well as other intertwined pedagogical variables. These features are then compared against a set of ideal criteria appropriate from an instructional design point of view. A number of evaluation forms and checklists have been designed in this way (e.g., Alessi & Trollip, 1991; Reeves & Harmon, 1994). A second type of evaluation is referred to as context-based evaluation since assess-

ment is carried out as the resource is used by the learner in a specific environment (Hosie & Schibeci, 2001).

Evaluation checklists

Checklists and evaluation forms have been criticised 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 students' interaction, analysing students' responses, and administering attitudinal scales (Hosie & Schibeci, 2001; Reeves & Harmon, 1994).

Although context-bound strategies are powerful tools in bringing about a whole picture of the effectiveness of courseware, when it comes to evaluating 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. Alessi and Trollip's (2001) evaluation form builds on the framework of Alessi and Trollip's (1991) quality review framework which addresses the evaluation of pedagogical features, interface design, navigation and user's control of an online resource.

Evaluation items for courseware (Alessi & Trollip, 2001)

- Subject matter;
- Auxiliary information;
- Affective considerations;
- Interface;
- Navigation;
- Pedagogy;
- Invisible features;
- Robustness; and
- Supplementary materials.

Evaluating websites

The exploration of 500 mathematics education websites, using the above evaluation form, highlighted some essential differences in design and usability issues between online resources and normal courseware. 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). Second, online resources differ from normal courseware in that the former do not come accompanied by a manual or printed instructions on how to teach with the resource. 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.

The following section presents a summary of the important features identified through the evaluation of a large number of websites.

Evaluation items for websites:

- Introduction;
- Displays;
- Motivation;
- Navigational aids;
- Questions;
- Self evaluation;
- Content structure;

- Directions;
- Learning metaphor;
- Methodologies;
- Format of feedback;
- User control;
- Language, style and grammar;
- Help.

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.

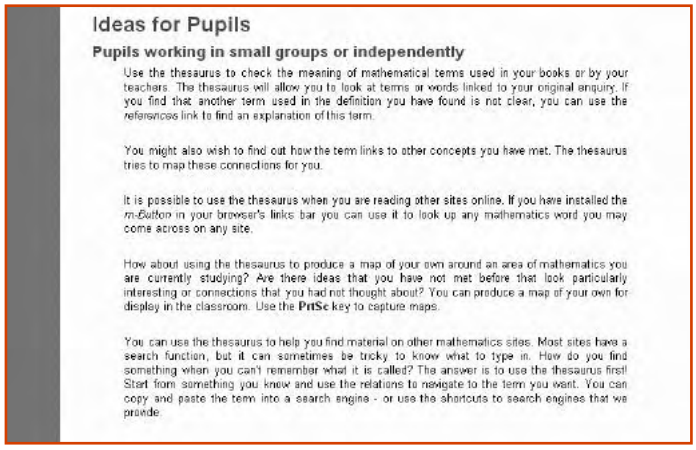


Figure 1.
http://thesaurus.maths.org/mmkb/view.html?resource=guides

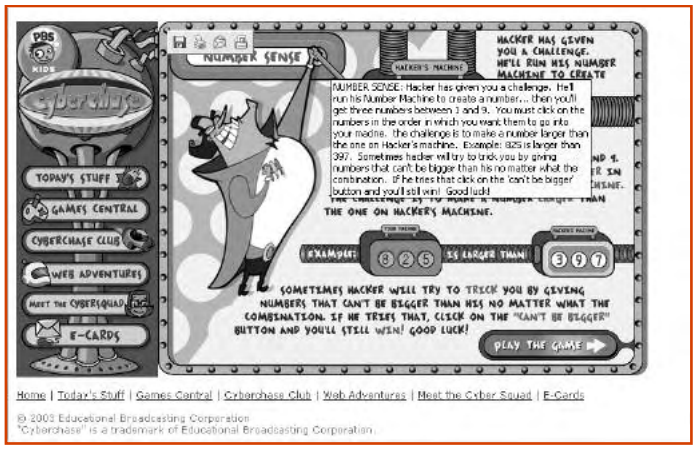


Figure 2. http://pbskids.org/cyberchase/games/numbersense

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. Figure 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 be consistent. Figure 3 shows a webpage with a dynamic percentage bar.

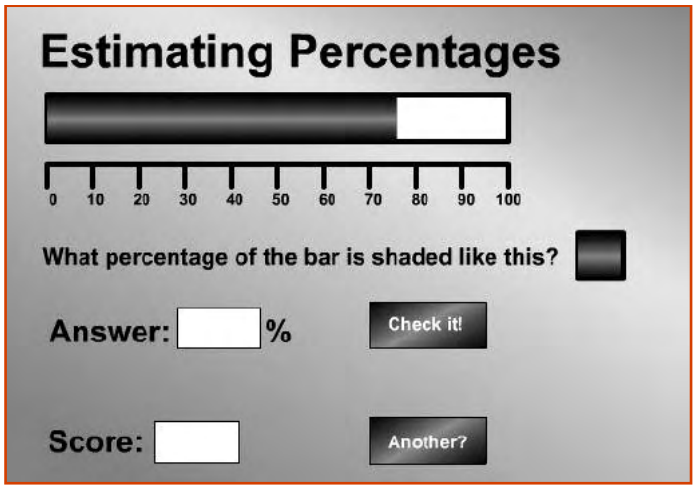


Figure 3. http://www.hellam.net/maths2000/percent1.html

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.

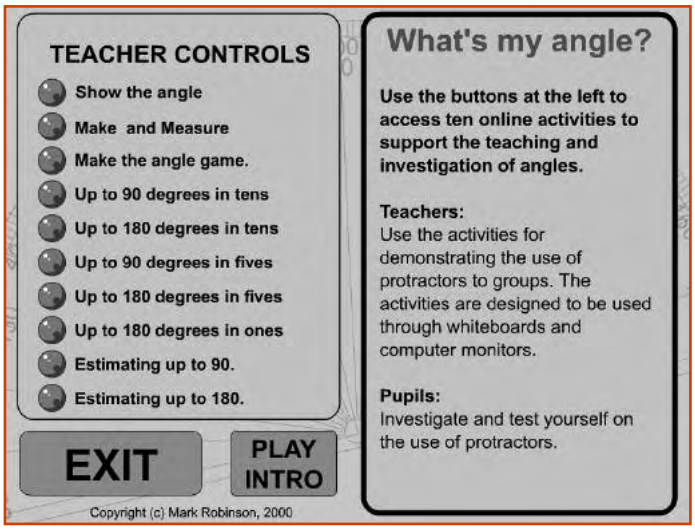


Figure 4. http://ambleweb.digitalbrain.com/ambleweb/ambleweb/ambleweb/mentalmaths/protractor.html

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.

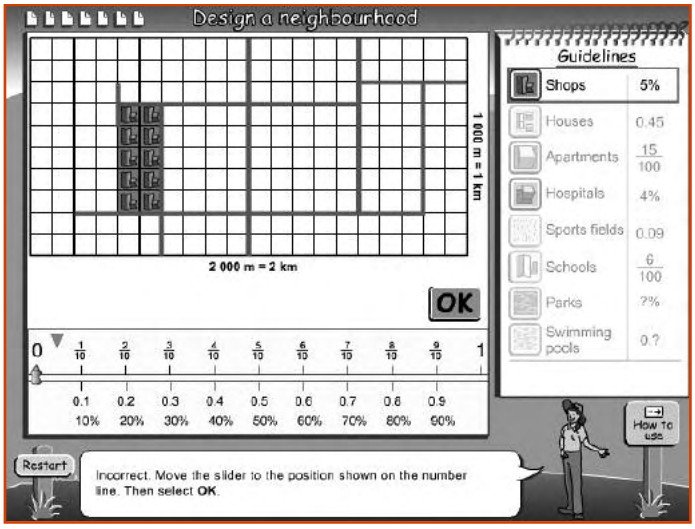


Figure 5.
http://www.thelearningfederation.edu.au/repo/cms2/tlf/published/10560/180204_education/L122_design_a_neighbourhood

Self-evaluation

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, among others, self-tests or quizzes which require "yes" or "no" or multiple choice answers, or comments on results in simulation activity. The activity in Figure 6 provides continuous feedback on the task.

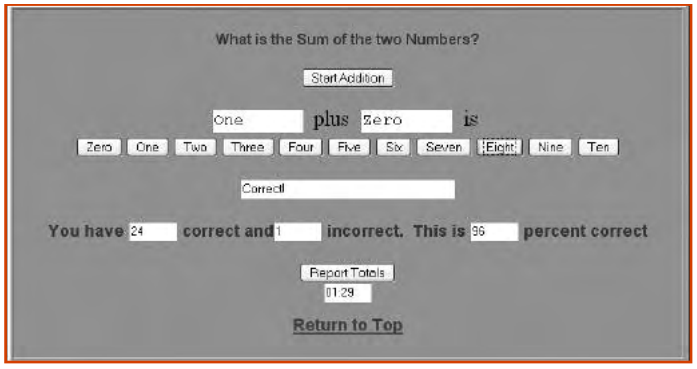


Figure 6. http://www.aaamath.com/B/addk7ex1.htm

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.

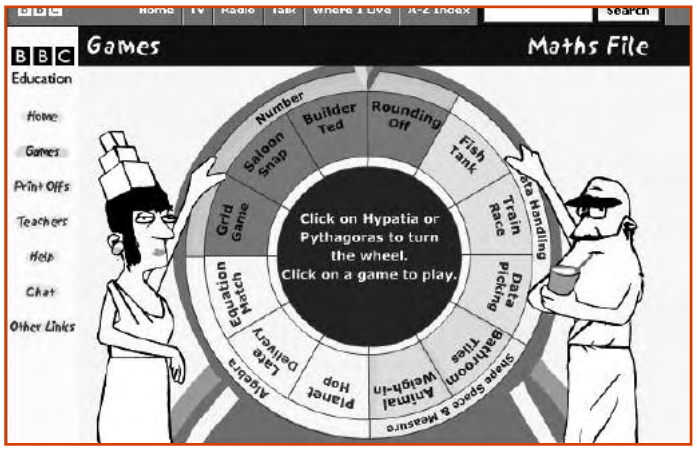


Figure 7.
http://www.bbc.co.uk/education/mathsfile/gameswheel.html

Directions

Advance organisers 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.

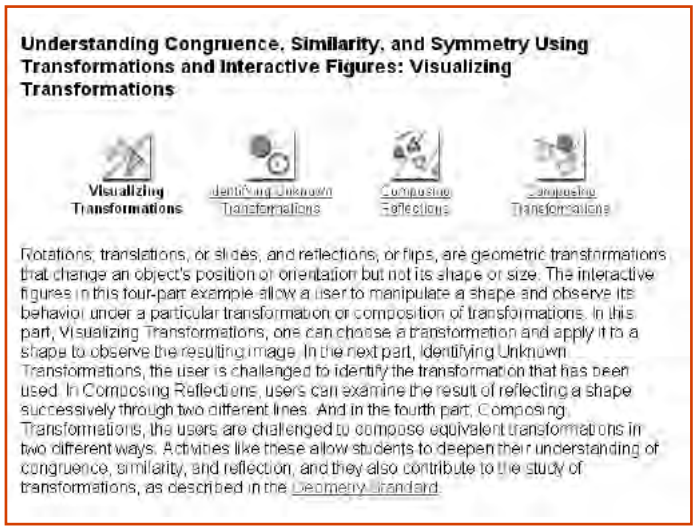


Figure 8.
http://standards.nctm.org/document/eexamples/chap6/6.4/index.htm

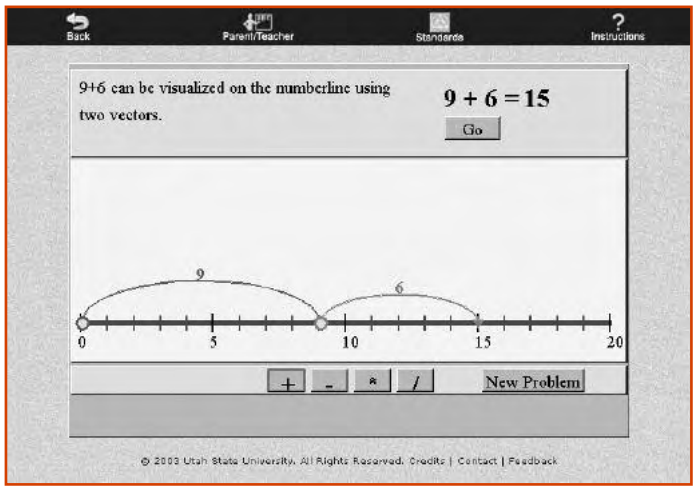


Figure 9.
http://matti.usu.edu/nlvm/nav/frames_asid_197_g_2_t_1.html?open=activities

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.

Methodologies

Student's interaction with the webpage should be more proactive than reactive. A proactive interaction emphasises 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.

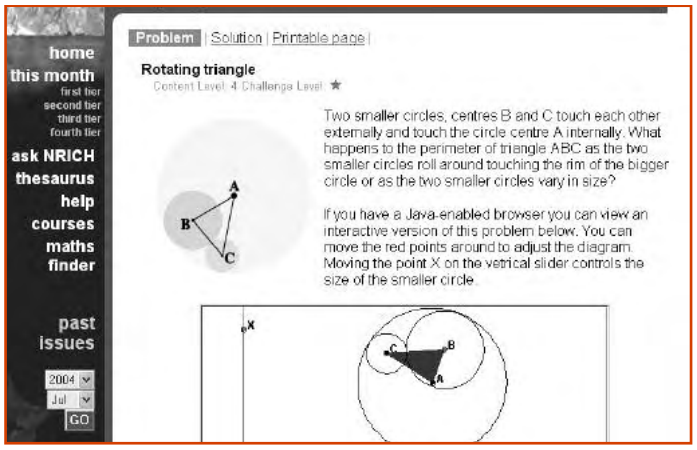


Figure 10.
http://nrich.maths.org/public/viewer.php?obj_id=266&part=index&refpage=monthindex.php

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.

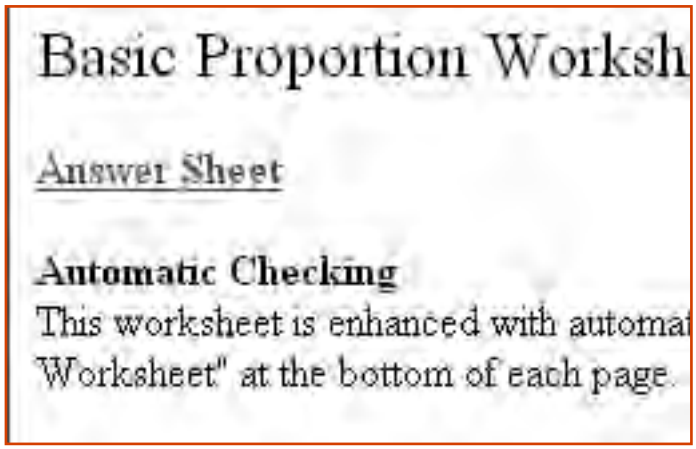


Figure 11.
http://www.algebrahelp.com/lessons/proportionbasics/pgw.htm

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.

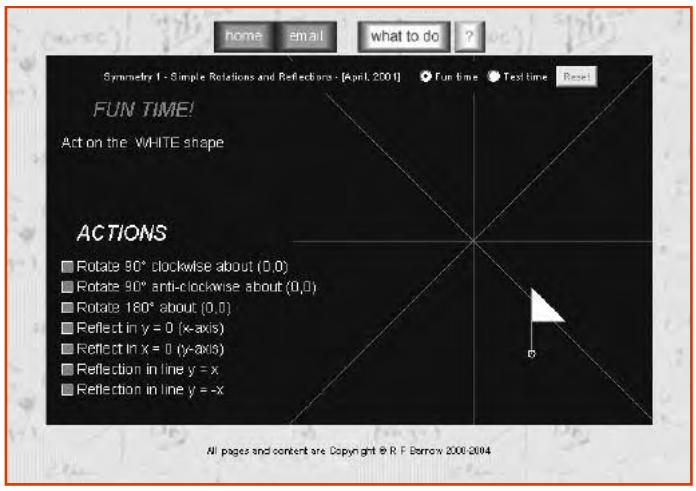
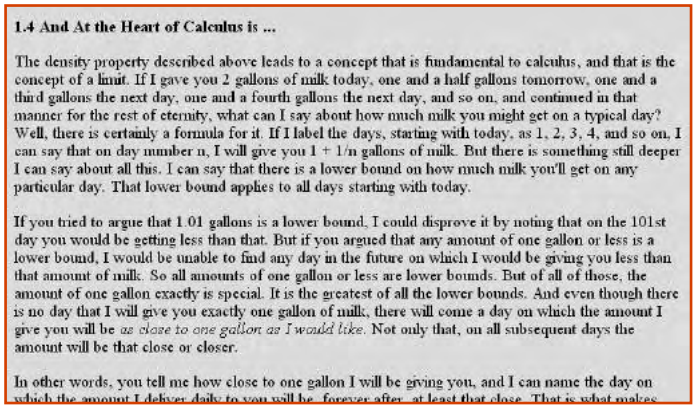


Figure 12. http://www.waldomaths.com

Language, style and grammar

Language and grammar should be at the appropriate reading level. Technical terms and jargon should be avoided as much as possible while spelling and punctuation must be thoroughly edited. Figure 13 shows a high lexical density text.



1.4 And At the Heart of Calculus is ...

The density property described above leads to a concept that is fundamental to calculus, and that is the concept of a limit. If I gave you 2 gallons of milk today, one and a half gallons tomorrow, one and a third gallons the next day, one and a fourth gallons the next day, and so on, and continued in that manner for the rest of eternity, what can I say about how much milk you might get on a typical day? Well, there is certainly a formula for it. If I label the days, starting with today, as 1, 2, 3, 4, and so on, I can say that on day number n, I will give you 1 + 1/n gallons of milk. But there is something still deeper I can say about all this. I can say that there is a lower bound on how much milk you'll get on any particular day. That lower bound applies to all days starting with today.

If you tried to argue that 1.01 gallons is a lower bound, I could disprove it by noting that on the 101st day you would be getting less than that. But if you argued that any amount of one gallon or less is a lower bound, I would be unable to find any day in the future on which I would be giving you less than that amount of milk. So all amounts of one gallon or less are lower bounds. But of all of those, the amount of one gallon exactly is special. It is the greatest of all the lower bounds. And even though there is no day that I will give you exactly one gallon of milk, there will come a day on which the amount I give you will be *as close to one gallon as I would like*. Not only that, on all subsequent days the amount will be that close or closer.

In other words, you tell me how close to one gallon I will be giving you, and I can name the day on

Figure 13. http://www.karlscalculus.org/calc1.html

Help

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

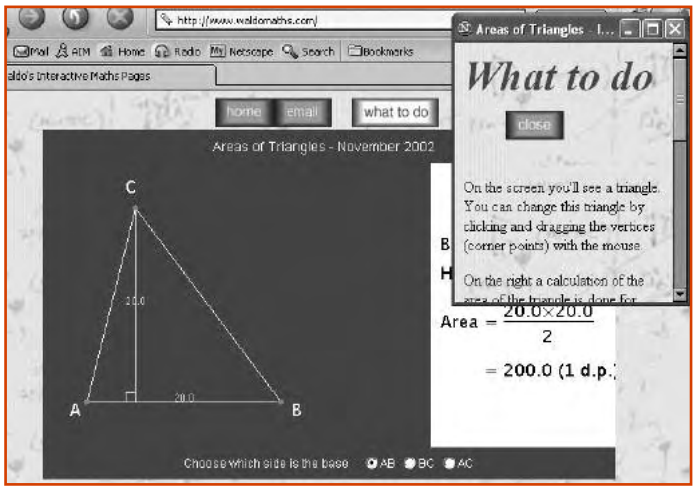


Figure 14. http://www.waldomaths.com

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.

Generally speaking, it was found that online resources created by professional organisations and organised in inclusive websites such as the Learning Federation (www.thelearningfederation.edu.au), Cambridge University (www.nrich.maths.org), the National Council of teachers of Mathematics (illuminations.nctm.org/imath), York University (http://www.counton.org) or the Shodor Foundation (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. The Teaching and Learning Exchange (TaLe) is a comprehensive educational portal for parents, teachers and students developed by the NSW Department of Education and Training's Centre for Learning Innovation. It provides access to a large range of resources that are organised by stages and by key learning areas. TaLe can be accessed at www.tale.edu.au.

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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Note

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