The impact of web sites on teaching and learning mathematics

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Abstract

The contribution presents an overview and analysis of research results concerning the influence of Internet on mathematics teaching and learning. The studies have been divided into categories according to their research focus. The second part focuses on free web resources. Website functions are being discussed in comparison to textbooks from the learning process point of view. Based on the investigation of a range of websites, the benefits and risks associated with web sites use in mathematics instruction are stated. These include an analysis of some mathematical and didactical errors in these resources.

1. Introduction

Recently, the use of modern technology, particularly PCs and internet connections in schools has been increasing. In the European Union, more than 96 % of primary and secondary schools are connected to the Internet (EC, 2006). The increasing significance of this technology for education is testified to by the fact the Internet and its use by pupils and teachers has become the subject of a number of studies (EC, 2006).

2. Research into Internet integration

Currently, only a few relevant studies on the impact of the Internet on teaching and learning mathematics are available (National Mathematics Advisory Panel, 2008). The majority of the studies focus on university students of other fields than mathematics. This is due to the fact that online teaching has no tradition at primary and secondary schools.

2.1. Impact of the Internet on knowledge and skill development

Given the fact that in education the Internet was first used for university distance courses, the studies undertaken in the late 1990s focused on the results of students whose distance education was supported by the Internet. First such studies include Wegner et al. (1999). This two-semester study compared the results of students (practising
teachers) achieved in the classical and online distance course on syllabus creation. Students included in the experimental group used email, videoconferences and received sets of problems to solve. The final test did not show any significant differences between the groups. However, some other studies focused on learning physics, financial mathematics and law showed better results were achieved by students whose instruction included online materials (Hill et al., 2004; Emmungil, Geban, 2010).

The latest research includes a year-long study carried out at German secondary schools (Graff et al., 2008). Students aged from 12 to 15 were divided into experimental and control groups. First, all students took a standardized pre-test to determine their knowledge of basic arithmetic operations. The pre-test was prepared in e-Fit, a website environment used only by the experimental group of students during the year. These students were using e-Fit to work on maths problems of increasing difficulty level twice a week. After completing a set of tasks, students were informed of their results and received follow-up sets of tasks. During other lessons, the work of the experimental and control groups did not differ. At the end of the experiment, both groups took a final test in the e-Fit environment. The experimental group of students achieved markedly better results in this test. However, the question is, whether their better performance was not influenced by the differentiated teaching methodology. The significantly better results may have also occurred due to the fact that the post-test was prepared in the e-Fit environment which only the experimental group of students used for their school work throughout the year.

Baki a Güveli (2008) focused on the use of websites in explanation of the concept of a function and practical problem solving at secondary schools for a period of five weeks. They studied the changes in student attitude towards lessons and their results. At each participating school, the students were divided into experimental and control groups. The pre-test did not show any differences between the two groups in terms of their input knowledge. The experimental group worked with websites during their lessons twice a week and the students also used them for their work at home. While the experiment was still underway, the teachers registered increased motivation and self-confidence in students in terms of learning and task fulfilment. In the knowledge and skills post-test, the experimental group showed significantly better results, especially in the improved understanding of various representations of functions. The teachers positively evaluated the interactive elements at the website and indicated that the concept visualisation and animation played an important part in teaching the students.

2.2. Online formative assessment impact

Other studies focused on the impact of online formative assessment on the learning process and its results. The study by Ricketts and Wilks (2002) carried out between 1999 and 2001 looked into the impact of online assessment of students in a university course of statistics. In the first year of the research, the students took a written test and in the subsequent years formative tests using the Internet. The 2000 online test was designed differently than the test in 2001 and the screen scrolling was eliminated. Average online test results in 2000 were significantly worse than those of written tests taken in the prior year. The test results in 2001, after the test design had been improved, were slightly better than the written test results from 1999. This indicates that test design may play an important role in the formative assessment impact.

In 2001, the impact of online assessment of students in the 8th year was examined using a standardized maths test (Sandene et al., 2005). The experimental group consisted of students who took the online test on a PC or being directly connected to the Internet. The control group took a written test which included identical questions. On average, the experimental group achieved a significantly lower assessment than the control group. The greatest differences between the groups occurred in the constructed-response items, smaller differences in the multiple choice items.

Another quantitative study focused on immediate feedback and its impact on the student maths results (Wang, 2011). Students of the 7th year at a lower secondary school were divided into three groups and all the groups used identical printed teaching materials. The first and second group were partly taught using the Internet where the students worked on solving sets of tasks. In the first group, each task was immediately evaluated. In the second group, students learnt the results only when the particular set was completed. Students in both groups then received new sets of task to practise the problems they failed to solve correctly. The third group did not solve their problems
on the Internet but only took written tests. After completion, they were briefly informed about their results but no follow-up activity was assigned. Overall, the best post-test results were achieved by students who received immediate evaluation after each task. No significant differences were found in the two remaining groups.

2.3. Internet search

Study by Puustinen et al. (2009) analysed spontaneous behaviour by students in the 6th–9th classes at lower secondary schools who used the Internet to help them solve maths problems. The research made use of the archive of the French Mathematical Forum which provides students free help with solving maths problems. The study aimed to determine, whether there are several ways of looking up help during the learning process and whether these ways correspond to the age of students. Only students of 15 years and older were capable of formulating comprehensible and polite questions. Younger students did not manage to clearly define their issue which might have influenced the level of the teacher help provided. This may also relate to the lower capability on the part of younger students to formulate ideas and the asynchronous communication in the internet environment. Rapid information exchange in this environment may evoke “real” communication in some users (Hill et al., 2004).

In her study, Sande (2011) focused on student behaviour in an online maths forum environment. The aim was to characterize mathematical activity of students formulating questions and their reaction to the help offered. She analysed one hundred questions and answers on the topic of the limit of a function step by step and one hundred questions and answers on applying derivatives. She found out that approximately one half of the students asked actively, i.e., the student indicated his/her solution or idea. The second most numerous group consisted of students who showed no mathematical activity in their questions. These were mostly students urgently asking for help because they did not understand the particular problem at all. She further observed that if help was provided by asking questions, students were subsequently more active and tried to find solutions themselves. This raises questions on the relationship between student activity and the type of help provided and leads to looking for factors impacting student activity.

3. Freely available website materials

The growing share of freely available websites supports a broader use of the Internet in teaching mathematics. Websites often contain images, videos and animations and thereby contribute to clear explanation and effective learning process. Internet materials may partially substitute printed textbooks and problem sets.

3.1. Website types

The freely available maths websites may be classified by various criteria, for instance according to their focus or student age. In terms of their scope and layout, they may be broken down into comprehensive websites (containing explanation, problems to be solved and tests), applet websites, online programme websites, mathematical encyclopaedias, mathematical libraries and maths online games. Based upon our experience and interviews with Czech secondary school teachers, it may be said that comprehensive websites and applet websites are most frequently used in mathematical instruction (Robová, 2012).

There is a lack of quality comprehensive websites simultaneously dealing with several topics. This is due to the fact that such websites are very difficult to create in terms of mathematics, didactics and programming. The quality English comprehensive websites include e.g., Illuminations (http://illuminations.nctm.org/). This website is designated to support mathematical instruction in the USA, ranging from pre-school education to secondary school instruction. It contains a large number of resources such as applets, lesson plans and worksheets.

Interactive website elements include applets. They are programs which users perceive as dynamic images. Applets are mostly used to deal with a concrete mathematical relations or concepts. Applets usually serve to practise new lessons, some also explain new issues based upon students active approach. For instance, WisWeb (http://www.fi.uu.nl/wisweb/en) contains applets designated for student population from 12 to 18 years of age.
3.2. Benefits and risks of Internet use during lessons

Teacher’s personality, including teacher’s attitudes towards technology play an important role in assessing the benefits brought by Internet use during lessons, along with school equipment and a number of other factors. If teachers decide to use freely available websites in their lessons, they should be aware of their benefits as well as certain limitations and risks. Based upon more than a decade of experience with looking for and making use of quality website resources in mathematical instruction on the secondary school and university level, we can say the key benefits of their integration lie in:

- access to a large number of teaching materials,
- increasing the clarity of explanation and learning effectiveness,
- student motivation and proactive approach,
- individual approach to instruction,
- possibility to test student knowledge and skills,
- availability and low cost.

Key issues with Internet use in instruction include the amount and quality of the information available. Experienced teachers should first assess the professional and didactical level of a particular website since the freely available materials are rarely reviewed and therefore may contain various errors and deficiencies. In terms of providing mathematical instructions, the major risks of website integration include:

- mathematical errors on the website (particularly on website created by students),
- didactical deficiencies in the preparation of teaching materials,
- time consuming searching for quality and freely available websites,
- increased demand for teacher lesson plan preparation,
- language barrier for foreign websites.

Mathematical errors present at the websites include false mathematical statements, incomplete and deformed the introduction of mathematical concepts (due to the effort to simplify the concepts and make them more accessible to students), incorrect procedures given for example problems, etc. Didactic shortcomings include a failure to respect the principle of clarity and adequacy of explanation adjusted for user age. They also include inappropriate methodology, didactical formalism, complex procedures and incomplete instructions for students.

Let us present some didactical shortcomings. Depicts an inappropriate method of procedure for working out a problem at the Czech Mathematical Forum (http://forum.matweb.cz/). The solution indicated is time consuming and complicated, the right portion of the image shows a more suitable solution we provided.

An example of an improper methodology is depicted in Fig. 1. The applet depicted is used for practising fractions (http://www.helpingwithmath.com/resources/games/fraction_game3/matching.html). Students must drag a fraction card to the location of an equivalent fraction. If students fail to move the card properly, it bounces back to the pool. Thus, students may match all the cards “correctly” without understanding fraction equivalency.

![Figure 1. Applet, equivalent fractions](image-url)
4. Conclusion

The ever broader use of modern technology, including the Internet, divides the user public into two basic groups based upon their understanding of the pros and cons of ICT integration: supporters and opponents. So far, the studies focusing on the impact of the Internet on the knowledge and skills of teachers and students have not provided unambiguous results (National Mathematics Advisory Panel, 2008).

If teachers try to use quality websites in their classes they are likely to find out after a certain period of time that their integration itself does not grant better results of the teaching process but does not make them worse either. These websites, however, may provide informed teachers with other ways of motivating and interesting students, increasing the clarity of explanation and including proactive methods in their classes.

References


