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Remediation with Math-Bridge

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Abstract

Math-Bridge is based on an ITS and is an e-learning tool for mathematics that can be used in various pedagogical scenarios: acquiring knew mathematical knowledge, revising known concepts, deepening knowledge or training competencies. We carried out an experiment testing Math-Bridge in a short revision session with 96 first-year students before their mathematics exam. In the experiment we proposed a limited content concerning binary operations and groups to work on autonomously as a revision session for the exam. Students filled out a questionnaire concerning usability and accessibility of Math-Bridge at the end of the session.

Keywords: intelligent tutoring system; Math-Bridge; remediation; mathematical bridging courses

1. Introduction

High drop-out rates among first-year university students in natural sciences because of lacks in mathematical knowledge is observed throughout European countries (Eurydice 2007). To provide a contribution in tackling this complex problem, the European project Math-Bridge aims to provide a multilingual e-learning tool that contains relevant mathematical content for typically first and second year university students in need for mathematical bridging courses. A large pool of remedial courses and training exercises is created for use and reuse across European universities. The platform is based on an intelligent tutoring system which adapts to the student users' field of study, competency level and progression profile. The tutorial component based on the learner's model makes this possible as well as the automatic and handmade generation of books that come along. Moreover the multilingual and multicultural aspects within presenting mathematics (Melis et al. 2009) play an important role: the content is available in seven (European) languages easing cross-cultural training and Europe-wide mobility.

2. Theoretical framework

2.1. Remediation and revision

Remedial courses are aiming at helping learners to catch up to a certain level of knowledge, often for students in difficulties (Brown 1999) whereas the activity of revision is often individual, and aims at refreshing knowledge and

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competencies once acquired, typically before an exam. So remediation and revision are similar activities, but the pedagogical conditions in which they take place differ.

2.2. Mathematics: concept of group

Several works deal with the difficulties of students of basic notions in group theory in mathematics, see for example (Lajoie 2000), (Lajoie 2001) and (Lajoie 2004). The characterization of the difficulties implies that the mathematical concept of group constitutes an epistemological obstacle, in the sense of Bachelard (Bachelard 1976). Briefly the mathematical definition of the algebraic structure "group" is the following: it is a set together with a binary operation verifying the group axioms, being closure, associativity, identity and invertibility. A commutative (or abelian) group is a group that verifies the commutativity axiom too. Many mathematical systems verify the group axioms (e.g. integers with addition, bijections on a set with composition). In the learning process students' conceptions of the group structure can be guided by examining proprieties of binary operations on different types of underlying sets: a discrete set (of numbers), a real interval, a set of functions on a discrete set, a set of linear transformations, etc.

3. Problem and Hypotheses

Since Math-Bridge claims to be a multi-sided e-learning tool, adapting to different remedial scenarios (Biehler et al., 2010), we decided to experiment Math-Bridge in one possible remedial scenario: revision session before an exam. We did deliberately not choose to use a wide range of all the possible functionalities of the platform, only the most basic ones. This restriction has several reasons. Firstly, a rather practical reason for considering a scenario with a small degree of liberty is that the analysis won't become too cumbersome and allows us to control certain parameters. Secondly, since our scenario is a very basic one with little possible interactions, it has to be checked that at least this usage scenario of Math-Bridge works well. If the proposed scenario is adapted to users' needs, we think that they are going to be satisfied with the usage of Math-Bridge, that they will succeed in solving the first four exercises during the one-hour session and that the usage of the solution and hint buttons allow to identify the applied exercise solving strategy.

4. Experimental situation

96 first-year students, divided in 4 groups, in computer science at the IUT Montpellier (France) took part in the experiment in May 2011. We proposed a set of 9 exercises to work on as a revision session of an hour, a few days before their mathematics exam. The exercises were arranged in an increasing order of difficulty, they included a hint and a solution button. Moreover basic definitions and results concerning the concept of binary operation and group were available and in some exercises some words were linked to detailed definitions. The exercises were all of the following type: given a binary operation on a set, check its proprieties (closure, associativity, identity, invertibility and commutativity). For the first exercises the proprieties to check were detailed in the question, for the later ones they were not. At the end of the session, the students filled out a usability and acceptability questionnaire (Nielsen, 2000).

5. Results

We traced each students' navigation on the platform, we collected the scratch papers and the questionnaires' replies. In this article we focus on the results of the analysis of the questionnaire only. The questionnaire contained 16 questions, 9 on how students used Math-Bridge (definitions, results, links, hint and solution buttons) together with an evaluation of the usefulness. The last 7 questions were about students' general opinion and impression of Math-Bridge, as well as about possible future usage. 95 of the 96 participating students filled out the questionnaire, so our data is based on these 95 individuals.

During the 1-hour-session, we expected that the students will mostly be working on the first 4 exercises, each one of them consists of at least two parts. This was indeed the case: over 50% of the students did not deal with the exercises 5 to 9, this is why we consider only the first four exercises in our analysis.

5.1. Questions about usage

Table 1 shows the results concerning the realization of the first four exercises, as well as the usage of the (hidden) links in the exercises.

Table 1. Realization and usage of the links of the first four exercises

Answers	Exercise 1	Exercise 2	Exercise 3	Exercise 4
I read it	1.05%	3.16%	13.68%	20.00%
I understood it	9.47%	6.32%	11.58%	4.21%
I started but didn't finish it	7.37%	18.95%	44.21%	30.53%
I finished it	82.11%	71.58%	27.37%	16.84%
I didn't deal with it	0.00%	0.00%	3.16%	28.42%
Used links	29.47%	25.26%	21.05%	8.42%

The students who used the links (35.79% of the students) were asked to mark their usefulness on a scale from 1 (not useful at all) to 4 (very useful), the mean is 3.00. The hint buttons were used by 81.05% of the students and the mean value of the usefulness is 3.29 (on the same scale as before). 70.68% of the students used the offered definitions page, the mean of usefulness is at 2.99 and 65.26% used the results page with a mean of 3.11. So these three features (hints, definitions and results) were used by most of the students and they are considered quite useful.
The usage of the solution button is one of the central issues concerning usage strategies of Math-Bridge in our given scenario. A priori, we identified the following five strategies:

1. After having read the exercise, the student doesn't know how to solve it, clicks right way on the solution button, tries to understand the correct solution and stops further working on the exercise.
2. After having read the exercise, the student doesn't know how to solve the exercise, clicks on the hint button which gives him some ideas how to proceed. He does some computations and reasoning, when he thinks to have finished the exercise, he clicks on the solution button in order to compare his solution with the proposed one and stops then further working on the exercise.
3. After having read the exercise, the student doesn't know how to solve the exercise, clicks on the hint button which gives him some ideas how to proceed. He does some computations and reasoning, when he thinks to have finished the exercise, he clicks on the solution button in order to compare his solution with the proposed one, his solution isn't correct and he decides to continue working on his solution.
4. After having read the exercise, the student doesn't know how to solve the exercise, clicks on the hint button which gives him some ideas how to proceed. He does some computations and reasoning, but doesn't succeed in solving the exercise. The hint not being a help any more, he clicks on the solution button, tries to understand the proposed solution and then stops further working on the exercise.
5. After having read the exercise, the student doesn't know how to solve the exercise, clicks on the hint button which gives him some ideas how to proceed. He does some computations and reasoning, but doesn't succeed in solving the exercise. The hint not being a help any more, he clicks on the solution button, tries to understand the proposed solution and decides to continue working on his solution.

These strategies can be coded as a combination of replies for the following four questions of the questionnaire:

- You solved the exercise without clicking on the solution button right away.
- You went back and forth between your solution and the proposed one.
- You clicked on the solution button when you thought to have finished the exercise.
- You clicked on the solution button when you were blocked while trying to solve the exercise.

Table 2 summarizes the results of the strategies.

Table 2. Strategies – solution button

Strategies	Exercise 1	Exercise 2	Exercise 3	Exercise 4
Strategy 1	1.28%	1.28%	1.64%	0.00%
Strategy 2	78.21%	64.10%	52.46%	36.84%
Strategy 3	2.56%	3.85%	3.28%	2.63%
Strategy 4	6.41%	7.69%	6.56%	10.53%
Strategy 5	0.00%	5.13%	6.56%	15.79%
non identified strategies	11.54%	17.95%	29.51%	34.21%

So we can see that most students seem to have followed strategy 2, although the percentage of the students using this strategy decreases from exercise 1 to 4. The percentage of students working by strategies 1, 3 and 4 are almost constantly low. Students using strategy 5 increase form exercise 1 to 4, but compared to strategy 2, their percentage remains low.

5.2. Users' opinions

Table 3 gives an overview of the proposed statements about usage scenarios.

Table 3. Usefulness

	fully agree	somewhat agree	somewhat disagree	fully disagree
This session was useful for your exam preparations.	37.89%	42.11%	16.84%	1.05%
This session helped to understand the notion of group better.	24.21%	42.11%	27.37%	5.26%
This session helped to master the notion of groups.	10.53%	20.00%	37.89%	26.32%

Most students think that the session was useful as a preparation for their exam, but they didn't feel that it really helped to fully understand the mathematical concept of groups.

Also three questions on user satisfaction were asked (replies on a scale from 1= not satisfied at all to 10 = very satisfied), see the means and standard deviation in Table 4.

Table 4. User satisfaction

Are you satisfied with your experience with M-B...	mean value	standard deviation
… and its functionalities proposed?	7.16	1.53
… and its usefulness for your studies?	7.09	1.73
… from a global point of view?	6.80	1.84

Students agree on a relatively high satisfaction with Math-Bridge. A question on difficulties encountered when operating on the platform was answered by a mean of 2.07 on a scale from 1 = no difficulties at all, to 10 = many difficulties with a standard deviation of 1.57. The students agree on having encountered very few difficulties.

A last question about possible future use of the Math-Bridge was answered mainly positively, that is, with a mean of 6.69 on a scale from 1 = not interested at all, to 10 = very interested with a standard deviation of 2.55. Among those who are interested, we asked a ranking of the possible scenarios of future usage, for revision, for training and for deepening (Table 5).

Table 5. Future usage

Usage...	fully agree	somewhat agree	somewhat disagree	fully disagree
… for revision	37.89%	42.11%	16.84%	1.05%
… for training	24.21%	42.11%	27.37%	5.26%
… for deepening	10.53%	20.00%	37.89%	26.32%

Revision seems to be the most interesting scenario for possible future usage, whereas for deepening knowledge Math-Bridge seems less adapted from their point of view. Since our organised session inteded to be a revision session and did not leave any possibilities to explore any further potentialities of Math-Bridge that might promote deepening knowledge, this result is in line with our expectations.

6. Discussion

The above analysis of our data shows that Math-Bridge users considered to have encountered only a few difficulties of manipulation, they think that the organized revision session was a useful preparation for their exam and they are mostly satisfied with Math-Bridge.

The majority of the students (over 70%) successfully solved exercises 1 and 2, whereas the exercises 3 and 4 were mostly started but not finished.

For the first exercise, almost all students can be placed with respect to one of the a priori identified exercise solving strategies, whereas for the fourth exercise, we cannot conclude on the strategies of over a third of the students. Another remarkable trend is that for the first exercise a large majority (78%) of the students has used strategy 2 and for the fourth exercise only about a third of the students (37%, which is still the majority, but much smaller). Given that the difficulties of the exercises gradually increase from exercise one to four, we can say that whereas for easy exercises students mostly click on the solution button after having successfully solved the exercise in order so compare their solutions with the proposed one (strategy 2), for hard exercises, there are many who abandon the exercise without having tried to solve it, and among those (less than the total number of students) who attempt a solution, the ways of using the solution button, and thus the solution, vary much more.

So far we presented only the results of the questionnaires but since they reflect only each students' subjective point of view, our further analysis will include the analysis of the scratch papers, as well as the traces on the Math-Bridge platform, and we will try to correlate them to the results of the questionnaire. Moreover intend to relate the results to the score in the exam in order to identify a possible impact (and its extent) of the revision session with Math-Bridge.

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