Integration of heuristics elements in the web-based learning environment: experimental evaluation and usage analysis

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Abstract

The article deals with possibilities of using heuristics, interactivity and feedback in electronic learning materials. The aim of the paper is integration of heuristics elements in the web-based learning environment and the evaluation of heuristics approach into education. The author presents experimental evaluation of efficiency of heuristics approach into learning and a detailed analysis of the user log-on data, on which we can better understand the rate of using of heuristics elements together with other course activities in an electronic learning environment.

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Keywords: Heuristics, interactivity, feedback, evaluation, experiment, usage analysis, log file, data preparation;

1. Introduction

Heuristics as an approach to achieve new knowledge was suppressed into background in last several years. For students were and still are given complete information- knowledge without any activity to prove the true of the statement or to find out the relations and principles by themselves. It causes, that students cannot connect particular relations into whole part. The analytical thinking connected with logic is not supported and developed. Development of the Information Communication Technologies (ICT) and their influence on education, respectively on learning, created space for teachers to use heuristics during the lesson again. The ICT give space for students for their own experimentation, discovering certain principles and larger interactivity. On the other hand, ITC give a greater motivation for given subject considering that the students have a positive relation to using IT technologies in their own daily life. With ICT help, heuristics as an approach for new knowledge achievement could reintegrate as a learning strategy in education again. The aim of the paper is integration of heuristics elements in the web-based learning environment and the evaluation of heuristics approach into education.

2. Heuristics

We tried to show one way of application of heuristics strategies and rules through the electronic course with interactive graphs. We designed an electronic course- The quadric function, equation and in-equation with...
interactive graphs. Students formed their own hypothesis based on assignments (answer the questions) and own experimentation. Later, they verified their hypothesis through interactive graphs. The assignments were designed according to heuristics strategies (Polya, 1990; Vrábel, 2005). First, they involved problems from daily life, later they focused on mathematics problems, which could be displayed by numbers, and at the end generally (abstract) defined. By the course creation, we kept two principles: principle of activity: students discover principles by themselves and principle of motivation: students start to be interested in given study materials with using this form (Lukáč, Engel, Buxár & Šveda, 2006). In addition to interactivity interactive graphs have character of visualization, experimentation, but mainly character of verification (Fulier, 2006).

We can also say that interactivity is closely connected with feedback; student receives an immediately respond after his/her activity or answer for assignment in the e-course. The respond, whether is true or false gives him/her help to verify and confirm in acquired knowledge.

3. Experimental evaluation of heuristics approach

The aim of the research was to design learning approach which involves heuristics strategies and IT technologies. On the basis of these requirements we designed electronic course with interactive graphs. We motivated by its creation (Fulier, 2006; Fulier & Šedivý, 2001; Polya, 1990; Vrábel, 2005).

The experiment was carried out at compulsory school- gymnasium, year 1st. The experiment was focused on a learning approach of the quadric function, equation and in-equation. On the basis of the answers for the given questions (assignments), student has created his/her own hypotheses, which were later verified by him/her with interactive graphs. At the end of each important part there was a summary, what is very important for student and what he/she should know. In the experiment we stressed students’ interactivity and motivation.

After studying given subject matter, students of both groups (experimental and control class) wrote a test which consisted of 6 tasks with total score 20 points (post-test). The experimental group (Tab. 1a) got much better score 15.78 points than control class with score of 11.84 points. It was a big surprise for us and “satisfaction” because control group had better score in pre-test.

Table 1. Results: (a) Descriptive statistics of pre-test and post-test; (b) ANCOVA, univariate tests of significance for the post-test

<table>
<thead>
<tr>
<th>Level</th>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Err.</th>
<th>-95%</th>
<th>95%</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>Pre-test</td>
<td>66</td>
<td>11.10</td>
<td>2.95</td>
<td>0.36</td>
<td>10.37</td>
<td>11.83</td>
<td>Intercept</td>
<td>1</td>
<td>369.12</td>
<td>338.65</td>
<td>0.000</td>
</tr>
<tr>
<td>Group</td>
<td>exp</td>
<td>34</td>
<td>10.46</td>
<td>3.03</td>
<td>0.52</td>
<td>9.40</td>
<td>11.51</td>
<td>Group</td>
<td>1</td>
<td>80.65</td>
<td>73.99</td>
<td>0.000</td>
</tr>
<tr>
<td>Group</td>
<td>con</td>
<td>32</td>
<td>11.78</td>
<td>2.76</td>
<td>0.49</td>
<td>10.79</td>
<td>12.78</td>
<td>Pre-test</td>
<td>1</td>
<td>309.60</td>
<td>284.04</td>
<td>0.000</td>
</tr>
<tr>
<td>Group</td>
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<td>15.78</td>
<td>1.34</td>
<td>0.23</td>
<td>15.31</td>
<td>16.25</td>
<td>Group</td>
<td>1</td>
<td>68.67</td>
<td>63.00</td>
<td>1.09</td>
</tr>
<tr>
<td>Group</td>
<td>con</td>
<td>32</td>
<td>11.84</td>
<td>1.71</td>
<td>0.30</td>
<td>11.23</td>
<td>12.46</td>
<td>Error</td>
<td>63</td>
<td>1.09</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Visualization of the results: (a) The means with error plot for post-test; (b) Categorized scatter plot for post-test x pre-test
Based on data in Table 1b, the zero hypotheses – the presumption that there is no statistically significant difference between the groups in the post-test score – was rejected at the 99% confidence level. It shows that the relation between the covariate – the variable pre-test and dependent variable post-test is statistically significant at the 0.01 level.

The graph visualizes the ANCOVA results. Figure 1a illustrates the means with error plot showing the post-test score with respect to pre-test score. There has been proven a statistical significant difference ($p < 0.01$) between observed groups, in favour of experimental group in final test.

The restricted condition of using of analysis of covariance is equity of the regression coefficient in each group. This condition is very often disturbs, which restricts using of analysis of covariance (Hvorecký, Drlík & Munk, 2010; Kapusta, Munk & Turčání, 2009). The significant interaction of quantitative and nominal factor means infraction of this condition. Then different groups’ means are depend on quantitative factor-covariate. The easiest way, how to verify this condition is to check categorized scatter plot (Fig. 1b) for each factor level. If the particulate lines have approximately equal slop, the condition is valid. In this case the condition is valid, due to that the lines have approximately equal slop (Fig. 1b). It means that the regression coefficient is approximately equal in both groups.

4. Usage analysis of course activities

With analysis of the user log-on data we can better understand the behaviour of the student in an electronic learning environment. We used log file that contains the entities from the e-learning course with 34 students in experimental group. For this purpose the following adjustments (corrections) are made (Munk, Vrábelová & Kapusta, 2010):

a) Data cleaning, data transformation, data integration.
b) Identification of sessions, where the session may be defined as a sequence of the steps, that lead to completing the concrete task (Spiliopoulou & Faulstich, 1999) or as a sequence of the steps, that lead to meeting the concrete target (Chen, Park & Yu, 1996). The simplest method is if we consider the series of clicks in a defined period of time, for example 30 minutes (Berendt & Spiliopoulou, 2000).
c) The reconstruction of activities of a web visitor. Taucher and Greenberg (Taucher & Greenberg, 1997) proved that more than 50% of accesses to web are via backward path. Here comes the problem with the cache of the browser. By the backward path, a query for web server is not running, thus there does not exist a record in the log file. The solution to this problem is path filling. With path filling we add these missing rows into the log file (Cooley, Mobasher & Srivastava, 1999).

By the data preparation we took into account recommendations resulting from series of experiments examining the impact of individual steps of data preprocessing on quantity and quality of extracted rules (Munk, Kapusta & Svec, 2009; Munk, Kapusta & Svec, 2010; Munk, Kapusta, Švec & Turčání, 2010).

In the following part we are going to describe the results of association rules analysis, which represents a non-sequential attitude to the data being analysed. We shall not analyse sequences, but transactions, i.e. we shall not include the time variable into the analysis. In our case transaction represents the set of visited course activities by student during one session.

The web graph (Fig. 2) visualizes the found association rules, particularly the size of the node represents the support of an element, the line-width - the support of the rule and the brightness of the line - the lift of the rule. We can see from the previous graph, which clearly describes the chosen associations that among the most frequently visited course activities belong: course, resource, book (support > 89 %), similarly as combinations of pairs of these activities (support > 89 %).

Similarly we can see (Fig. 2), that the course activities - heuristics elements and assignment - occur more frequently jointly in the sets of visited activities of the course than separately ($lift = 1.3$). The same applies to the course activities - heuristics elements, quiz ($lift = 1.2$) and assignment, quiz ($lift = 1.2$).
In these cases the highest rate of interestingness was found (lift), which specifies how many times more frequently the visited activities occurred jointly than if they were statistically independent. In case that the lift is higher than one, the selected couples occur more frequently jointly than separately in the set of visited course activities by students in each session.

However, it is necessary to become aware of the fact that upon characterizing the rate of interestingness – lift, the orientation of the rule makes no odds. In case of the remaining found rules the value of the lift was approximately one.

5. Conclusions

With designing of heuristics approach of learning, using electronic course with interactive graphs we tried to regard several aspects, namely Recommendation of the European Parliament and of the Council on Key Competences for Lifelong Learning (The European Parliament and the Council of the EU, 2006). On the other hand, we tried to transfer traditional school into modern with implementing heuristics methods and new IT technologies (Vrábel, 2005; Fulier, 2006).

IT technologies create space for teachers to use non-traditional methods, namely heuristics like for example experimentation, creating hypotheses and their verification. That means for students motivation for given subject and also the space for their work at their own and speed and absorb new knowledge better.

During experimentation we noticed an interest in mathematics of weak students, what could have been caused they worked in his/her speed and each his/her opinion could be verified through interactive graphs or a general summary (which is at the end of each important part) or asking teacher who plays a very important role, role of tutor or director. The second factor which influenced students’ activity mostly was fact, that students could use a computer. We used students’ interest in computer. It motivates them and encourages their activity and interest in given subject.

From the analysis results, we came to conclusion, that students from the experimental group have better knowledge of given subject matter and gained better skills by the problem solving focusing on quadric function, equation and in-equation.

The results of usage analysis showed that the students mostly used heuristics elements by handling assignments and self-testing. The highest rate of interestingness (lift) was achieved for a pair of activities’ combinations
assignment, quiz and heuristics elements. These activities allowed them to examine or verify their own designed hypothesis. It was showed, that integration of heuristics elements into the electronic course was efficient.

References


