Eötvös Loránd University
Faculty of Education and Psychology
Doctoral Programme of Educational Studies

THESES OF PH.D. DISSERTATION

ANDOR ABONYI-TÓTH

DESIGNING COLLABORATIVE, INTERNET-BASED LEARNING PLATFORMS AND EVALUATING THEIR ROLE IN LEARNING

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1 INTRODUCTION

At the end of the 20th century we could witness the emergence and strengthening of some (interconnected) processes that have brought about revolutionary changes in the field of learning and teaching, as well as communication. Our communication habits have been altered by the wide array of multimedia services provided by the internet, and the spreading of mobile communication has changed the way we communicate and it changed the whole of society, which we have started to call information society. The changes in communication have implied sweeping changes in teaching and education, too. With the spreading of mobile internet, web services have become available (almost) anywhere, at any time, and this has made learning, among other activities, independent of place and time as well (Nyíri 2008).

As e-learning has become widespread, the opportunities of multimedia (pictures, animation) in learning content and materials were used more frequently, but real interactivity was missing, so learners passively received, downloaded and viewed the information. The functions of the first Learning Management Systems (LMS) appeared in the early 2000s and they facilitated student activity. This process was further improved owing to the new web generation (Forgó 2009).

Turcsányi-Szabó (2011) emphasizes the change in the process of transmitting information in the course of the development of the Web. Web 1.0 was characterized by the one-way flow of information. Then the passive consumption of information changed, and collaboration, common creation was emphasized (two-way Web 2.0). Finally, the retrieval of the necessary information has become possible (Web 3.0), tailored to the needs of the user, personalized, using the location finding applications typical for mobile devices. Upcoming changes in technology (which may be difficult to predict) are changing the process of education too. The author finds that the development of web technologies supports the process of student-centred learning, in which the transmission of knowledge by the teacher generates a collaborative knowledge building process, and the process reaches its peak in learning presence. So each Web generation has its own generation of learning process.

However it holds for each Web generation that as far as contents and services are concerned, equal access is not granted to everyone. For example, a blind user can only access applications that are compatible with screen reader software (or a Braille-display), and in the case of content, there should be text- or voice-based alternatives for visual information. For physically disabled people, applications should be operable without using the mouse, only with the keyboard, while other users may only be able to handle the mouse, or some other alternative pointing device (joystick, headmouse, footmouse), so for them, the function of the keyboard should be replaced. For those with hearing impairment, auditive information should be replaced by text, or sign interpreting. The list is far from excessive, there are numerous user groups that can be considered disadvantaged from an info-communicational point of view. Their needs should be considered carefully when creating contents (e.g. learning material), designing and developing applications.

There are various definitions given by researchers for the next generation of Web (Web 3.0). Kapp & O’Driscoll (2010) find that virtual worlds dominate in Web 3.0, while other researchers consider the Semantic Web the next generation (Tim Berners-Lee 1998). The latter philosophy dominates my dissertation, as my objective is to develop a semantic knowledge base as well.
2 RESEARCH AREAS

My research activities were focussed on the following two fields:

1st field of research

Reviewing standards, recommendations, methods supporting equal access to internet-based (collaborative) platforms, investigating concrete platforms from the viewpoint of equal access, developing models for creating accessible e-learning materials, and developing the framework connected to this.

As a university lecturer, teacher and developer of e-learning material and learning instruments I find it essential that collaborative web-based applications and e-learning materials developed for students should be available for an extended group of users, including those with disabilities. In order to be able to reach this aim, I had to become familiar with the standards, recommendations in the field, review the literature and collect the methodological principles essential for designing and developing accessible applications that guarantee equal access to these tools for everyone.

During my research I found that the standards and recommendations in the field - which are sometimes also available in Hungarian - give diverse and detailed information on the principles one should observe when creating accessible on-line content. However, these are not suitable for active teachers, who create supplementary materials and e-learning modules, or apply frameworks to solve problems in their daily practice, as the standards do not give an appropriate overview of the methods. This was my motivation for preparing a description, based on the principles laid down in the literature and standards, put in the context of education/learning, with examples. This framework gives a clear overview of the needs of different user groups for developers of learning materials/frameworks.

We can use various systems to support on-line learning. Besides making learning contents available, these systems also provide communication and collaboration opportunities. I have investigated several popular learning management systems from the viewpoint of fulfilling the the minimal accessibility requirements set in the WCAG 2.0 standard, and also surveyed to what extent university students are concerned with creating accessible frameworks and e-learning materials.

Reviewing the literature has helped me in defining the relevant meta-information (for other researchers and developers as well) that are essential for publishing multimedia elements (pictures, audio and video content, animation), and other components (tables, downloads) in an accessible way.

My research activity partly focussed on designing and implementing a framework and methodology suitable for creating accessible e-learning materials. The following research questions are related to this topic:

- Can an accessible, HTML-based e-learning material format be created using the present client-side technology (e.g. JavaScript) that can ease or terminate the accessibility problems experienced in learning management systems (e.g. the difficulties blind users have with navigation platforms)?
- What meta-information should be collected for creating accessible e-learning material?
- What is the most effective way to collect this information from the authors of learning material?
- Can the development of e-learning material be automatized, and if yes, what requirements should be met and developments need to be carried out?

2nd field of research

Designing, creating and uploading a knowledge base that relies on the opportunities of the semantic Web and can be used in education, in the framework of collaboration between the students.

I have participated in developing and teaching courses on web development at the Faculty of Informatics at ELTE since 1999. When developing web content, we have to consider various specifications, standards and recommendations, for different periods of time. However these documents cannot serve as reliable sources of information in the course of their autonomous learning activity.

There is a clear need for giving the students a modified version of the most important basic standards of web-development (HTML, CSS, WCAG 2.0), completed with methodological adaptations, examples, interactive tasks and self-check questions. Another issue of crucial importance in my view is that the connections between the elements of external standards should be defined precisely in order to help students understand the relationship between these and enable them to use the connections as navigation tools and browse the knowledge base in a way that is optimal for their learning aims. In order to be able to achieve this aim a framework should be created that can store the semantic connections between the data and support effective searching in the content.

In order to be able to develop the framework and the knowledge base stored in it I conducted action research, in which I employed the methods of design-based research. Besides developing the education objective set at the outset of the investigation I also wanted the students to upload the content of the knowledge base in the framework of a collaborative process. My long-term goal was to make the content of the knowledge base accessible for everyone.

After having developed the framework the students worked out the keywords of the knowledge base. As we had to keep in mind the different motivation, activities and results of the student groups, individuals and tutors, we needed a framework that could help us model the expected activities. The framework I have used was ENGeström's second and third generation activity theory. (ENGeström 2009)

After the phase of uploading the knowledge base I investigated the students' experience with the framework and the effectiveness of group work with the help of a survey. The content uploaded to the knowledge base made it possible to compare the methods students use to solve search tasks in a traditional web-based search and in semantic search tasks. The students were also asked about the level of difficulty the perceived in the different tasks.
3 RESEARCH METHODOLOGY

I applied several methods in the course of my investigations. As a practising university lecturer I chose the action research method to find answers to the pedagogical questions concerning the development of a suitable, modern semantic knowledge base that can reveal the deeper connection between data and fulfills the students’ expectations. In the framework of the action research, special applications needed to be developed. This was realized within the framework of a design-based research project. In the different cycles of my action research I conducted several surveys with the students at the Faculty of Informatics at ELTE. I also conducted a number of semi-structured interviews in order to be able to investigate some special areas in more detail. For the analysis of the students’ activity in the semantic knowledge base the data stored in the data base had to be retrieved. In order to be able to do this I had to become familiar with the role of the tables and fields that make up the data base, and I had to formulate the queries that could provide suitable input for statistical analysis in the SPSS19 application.

3.1 Action research

The concept of action research is defined in the Hungarian Pedagogical Lexicon (Pedagógiai Lexikon, 1997:38) as follows: ‘... action research is a type of pedagogical research that a person working in the practice conducts in order to better understand and improve their own practices, and to get to know the framework of the situation better’.

ÁGNES VÁMOS (2013) in her analysis of the history of action research in science points out that the roots of action research lead us back to the work of DEWEY who defined learning as something "accompanied by activity with reflection, trial and experiment" and emphasizes the importance of 'learning by doing'. The concept of action research was originally defined by the psychologist KURT LEWIN in the 1940s. He described the main phases of action research as a spiral of steps: 1) diagnostics, 2) planning, 3) starting the first phase, 4) action, 5) observing the action, 6) and planning the new phase, after having evaluated the previous experience. In action research theory, practice and observation are present at the same time and these three exert their joined effect with growing intensity.

HAVAS (2004) in his article uses the definition by KEMMIS as a starting point that claims that action research 'is a form of operational technology, and at the same time, the evidence that realizing educational (teaching-learning) goals can be partial, fractional too, and it is a moral and ethical attitude, which identifies improving human life as its objective'. In action research, the steps of planning, action, observation and reflection follow each other in a cyclical way.

At the beginning of the 2000s several studies were published on the topic of action research (HAVAS 2004, HAVAS & VARGA 2006) and two doctoral dissertations were written in Hungary (FŰZNÉ KÖSZŐ 2006, BODORKÓS 2010). In 2012 the results of a large-scale action research study were published, edited by VÁMOS and LÉNÁRD. In the latter study, the Pedagogy BA at ELTE Faculty of Education and Psychology was monitored from the beginning to its educational reform in 2011.
3.2 Design-based research

WANG & HANNAFIN (2005:p.6) give the following definition of design-based research:

...a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories.

Researchers give this approach different names in the literature: "design experiments", "design research", "design based research", "development(al) research", and "formative research" (HERRINGTON ET AL. 2007).

Education researchers discovered these methods at the beginning of the 1990s, when laboratory experiments, and comparing results of and drawing conclusions from experimental and control groups became less frequent in investigating the effectiveness of different teaching methods. According to SCHOLENFELD, who also conducted 'laboratory' experiments, this approach might be problematic, because the objectives of education have changed, and teaching and learning the material is not the sole objective any more. Laboratory experiments with strictly controlled variables cannot be used in the classroom without alterations, and during the implementation of the methods, new theories might be formed. So research is not just about testing hypotheses, but also generating new hypotheses (SCHOLENFELD, 2006).

COBB AND HIS COLLEAGUES (2003) emphasize the following features of design-based research:

1) They seek to develop theories about the process of learning and the means to support that learning.
2) They are highly interventionist in nature.
3) They test theories, during the process of which new ones form.
4) They contain cycles of iteration.
5) They are pragmatic.

According to the DESIGN-BASED RESEARCH COLLECTIVE\(^1\) (2003) good design-based research has the following five characteristics:

First, the central goals of designing learning environments and developing theories or "prototheories" of learning are intertwined. Second, development and research take place through continuous cycles of design, enactment, analysis, and redesign (Cobb, 2001; Collins, 1992). Third, research on designs must lead to sharable theories that help communicate relevant implications to practitioners and other educational designers (cf. Brophy, 2002). Fourth, research must account for how designs function in authentic settings. It must not only document success or failure but also focus on interactions that refine our understanding of the learning issues involved. Fifth, the development of such accounts relies on methods that can document and connect processes of enactment to outcomes of interest.

AMIEL & REEVES (2008) find that design-based research integrates the solutions to problems experienced in the learning environment and the identification of reusable design principles.

\(^1\) http://www.designbasedresearch.org/
The differences between predictive and design-based research are demonstrated by a process diagram.

Figure 1. Predictive and design-based research approaches in educational technology research  
(Based on AMIEL & REEVES 2008:FIGURE 1)

When introducing my own design-based research I described the phases of the above-mentioned process diagram in detail.
In the following section I am going to summarize the features of the survey research I conducted in the different phases of the action research and the fact finding phase.

<table>
<thead>
<tr>
<th>The name of the research phase</th>
<th>@IK 2011 (survey)</th>
<th>@IK 2012 (survey)</th>
<th>Web development I. course, post-survey (2012/2013. I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target group</td>
<td>Students from the Faculty of Informatics at ELTE</td>
<td>Students from the Faculty of Informatics at ELTE</td>
<td>Students participating in uploading the keywords of Wiki semantic knowledge base - collaborative group work</td>
</tr>
<tr>
<td>Type of investigation</td>
<td>anonymous, on-line survey</td>
<td>anonymous, on-line survey</td>
<td>anonymous, on-line survey</td>
</tr>
<tr>
<td>Aim of investigation</td>
<td>Finding out about the students' habits of internet use, access to instruments, expectations about computer-assisted learning, familiarity with group work.</td>
<td>Finding out about the students' use of community media services and their preferred forms of communication.</td>
<td>Finding out about the students' opinion and experience (participants of the collective group project of uploading the keywords of the semantic Wiki environment)</td>
</tr>
<tr>
<td>Type of questions</td>
<td>closed- and open-ended questions</td>
<td>closed- and open-ended questions</td>
<td>closed- and open-ended questions</td>
</tr>
<tr>
<td>Sample size</td>
<td>275</td>
<td>342</td>
<td>134</td>
</tr>
<tr>
<td>The name of the research phase</td>
<td>Web development I. course, pre-survey (c2013/2014. I.)</td>
<td>Investigating solving semantic search tasks (survey) (2013/2014. I.)</td>
<td></td>
</tr>
<tr>
<td>Target group</td>
<td>Students in the Web development I. course</td>
<td>Students in the Web development I. course</td>
<td></td>
</tr>
<tr>
<td>Type of investigation</td>
<td>on-line, not anonymous survey</td>
<td>on-line, not anonymous survey</td>
<td></td>
</tr>
<tr>
<td>Aim of the investigation</td>
<td>Finding out about the students' previous knowledge about the topic of the course, and their familiarity with performing different types of web-based searches</td>
<td>Finding out about the students' effectiveness in performing search tasks in the semantic knowledge base, their perception of task difficulty, and their positive and negative experience related to using the system</td>
<td></td>
</tr>
<tr>
<td>Type of questions</td>
<td>closed- and open-ended questions</td>
<td>closed- and open-ended questions</td>
<td></td>
</tr>
<tr>
<td>Period of data collection</td>
<td>9-18 September 2013</td>
<td>16 October-18 November 2013</td>
<td></td>
</tr>
<tr>
<td>Sample size</td>
<td>276</td>
<td>231</td>
<td></td>
</tr>
</tbody>
</table>

In order to complete the results of the @IK 2011 study and find out about students' expectations about creating non-discriminatory e-learning material I conducted semi-structured interviews with a group of students chosen at random. Data collection took place between the 16 and 18 May 2011, with 16 university students as respondents.
4  THE STRUCTURE OF THE DISSERTATION

In the first chapter of my dissertation I describe my motivation for choosing this topic briefly and introduce the possibilities and obstacles of computer-assisted collaboration.

In the second chapter of my dissertation I describe the fields, methods and objectives of my research and describe the data collection and analysis methods I applied.

In the third chapter of my dissertation I discuss the importance of ensuring accessibility in internet-based learning environments. I review the key terms related to on-line learning environments and the main principles employed in designing human-computer interaction. Then I describe the design strategies and standards that support accessibility, review the relevant literature and summarize the main points that should be kept in mind when selecting an on-line learning environment, creating content, and developing e-learning material in a way that the system and material are accessible, usable and processable for a broad audience. I also provide my own examples and give practical advice on how to achieve these goals.

In the fourth chapter I describe the results related to the usability of learning environments and investigate their accessibility, using my own results from the investigations I carried out at the university.

In the fifth chapter I present the phases of the design-based research project that aims to set up the framework and methodology for designing accessible e-learning material.

In the sixth chapter I describe the design-based research process as part of an action research project that focuses on creating a semantic knowledge base in web development. The action research project had four phases. First, the framework that suits the expectations was created. Second, the keywords of the knowledge base were uploaded by the students collaboratively, third, the keywords were completed, corrected, evaluated and classified, and fourth, the strategies used by the students in semantic searches were investigated, and their perception of task difficulty, and positive and negative experience with using the knowledge base were identified.

The last, seventh chapter of the dissertation contains the summary of results.
5 HYPOTHESES, RESEARCH RESULTS

In my research project I have investigated the following hypotheses:

(H1): There is a stark contradiction between the functions of frequently used learning management systems (LMS) that make the publication of learning material possible and support collaboration between learners, and the minimal accessibility guidelines laid down in the WCAG 2.0 standard. So there is no equal access to the functions of the system and the learning contents.

This hypothesis has been justified after I reviewed the relevant literature (Hahn et al., 2013; Pataki, 2009; FeHér, 2012). In the widely used systems Blackboard 9.1, Desire2Learn 10, Moodle 2.3, SAKAI 2.8, ILIAS 3.10 shortcomings have been identified that make it obvious that these systems do not even meet the minimal requirements of accessibility. There was only one LMS (Atutor) that was developed with the requirements of equal access in mind, but this framework has not become widespread due to its limited functions.

The outcome one the investigation has made it clear that when developing e-learning materials the creation and application of new solutions is needed that enable the user to use certain functions independently (e.g. navigation between the modules, organising concepts, evaluating self-check questions). These functions were included in the different systems.

(H2): I expect that at least half of the participants of the @IK 2011 research project regularly engage in on-line learning activities even at locations that are not ideal, because of the noise, or because only short-term engagement is possible (e.g. during a journey), and this makes realizing equal access to materials even more important.

The results of the investigation show that (N=257) 53% of the participants regularly engage in such activity. The results emphasize the importance of creating accessible materials, as students will not hear the sound of the educative video, or any other sound in a noisy environment, so it's important to provide subtitles and transcripts to the videos. When using the internet outdoors, light conditions are also far from ideal, it is hard to see the screen, so extra attention should be paid to contrast in the materials, and a high contrast version and larger text-size should be available, etc.

(H3): Concerning the information-finding habits of the participants of the @IK 2011 research project I expect that in case they cannot find something in a module of the e-learning material they first try to find it with the search engine integrated in the system, and if this does not yield the desired result, they resort to the external search option.

My hypothesis has not been justified, as most participants said that they use the external search option first, in Hungarian, and using the integrated search system of the portal was only second on the list. This is an important insight from the viewpoint of my developments, as one of the main advantages of the semantic knowledge base is the option for refined search. Students who prefer external search engines miss this opportunity. This is why it is crucial to call the attention of the users of the knowledge base to the opportunities provided the internal search system, and an intuitive platform should be built in.

(H4): My expectation is that the ratio of students among the participants of the @IK 2011 research project who already participated in computer-assisted collaborative projects at secondary school is less than 25%.
Following the plans of the action research the students were to upload the keywords of the semantic knowledge base in the framework of computer-assisted group work. Having reviewed the literature I did not expect that the students would be familiar with this work form from secondary school. Unfortunately, my hypothesis has been justified (N=275) 19% of the respondents said that they had no previous experience with computer-assisted group work from secondary school. The results confirmed my presupposition that computer-assisted group work would be a novelty for the students of the Web development course (who take the course in their first year). They should be prepared for the course by the tutors and by collecting supplementary material.

(H5): My hypothesis is that the participants of the @IK2012 research project mostly prefer communicating through e-mail when working in a group collaboratively.

In the survey done in the @IK 2011 research project e-mail was the most common form of communication among the participants. My hypothesis was that they would prefer this form of communication when working in a group. This has not been justified, because the results showed that they mostly preferred meeting in person, and e-mails got only the second place. I concluded that there were no obstacles in the way of meeting in person when doing the planned group work, as the members of the group were regular students of a course at the same university.

H6: The overwhelming majority (>=90%) of students participating in uploading the Semantic Wiki knowledge base thinks that the distribution of scores in the group is fair, as they all had the opportunity to represent their own interests during the distribution of scores.

After the evaluation of the tasks carried out in group work scores were assigned to the groups, and the members of the group had to agree on the distribution of scores according to the amount of work done by each participant. As the students could represent their own interests within the group, and the distribution of points was based on consensus, I expected that the overwhelming majority (>=90%) of students would think the distribution was fair. The answers showed that (N=134) 80.5% of the respondents were satisfied with the distribution of scores. This figure is lower than the 90% expected, and the diversion is significant (p=0.001) given a one-sided alternative hypothesis, so the hypothesis cannot be justified. The students were given the option of motivating their answers in the survey. This enabled me to identify a number of problems. In the future I will call my students’ attention to ways in which they can avoid these problems.

The students were also given traditional web-based and semantic search tasks. The students scored the difficulty of the traditional and semantic searches. I calculated the averages of the two types separately, and ran a paired two-sample t-test to compare them. I set up the following hypothesis before the investigation:

H7a: I expect that the students find the typical search tasks in the semantic knowledge base (that can be carried out without using a special query language) more difficult than the traditional web-based tasks.

Concerning hypothesis H7a the results show that students found the semantic searches more difficult and gave higher scores, so the hypothesis has been justified.

(H7b): I expect that the majority of students (>=50%) evaluates these semantic search tasks as posing average, or weak difficulty.
In the investigation (N=225) 85% of the respondents thought that the semantic search tasks were of average difficulty at most. This figure fits the at least 50% expected, and the diversion is not significant (p=1) given a one-sided alternative hypothesis, so the hypothesis can be justified.

5.1 Usability of the results

Based on my research results a metainformational description was prepared that is relevant for every teacher and developer who aims to produce non-discriminatory learning materials. A further product of the investigation is the methodological description mentioned above that introduces the needs required by special user groups for e-learning materials (and systems). The methodology I have worked out for developing e-learning materials and the process descriptions provides a sound basis for learning material developers who aim to produce non-discriminatory learning materials. The semantic knowledge base has become freely accessible to every tutor, student, and professional interested in modern web development.

5.2 Suggestions for further research

After the further developments of the semantic knowledge base newer, independent fields of research will become open, which may even employ a multi-member research team. Possible topics:

- Investigation of the use of the semantic knowledge base in micro learning.
- Investigating the collaboration for creating, extending, correcting Wiki entries, with the help of data-mining methods.
- Developing and evaluating the use of intuitive platforms that support semantic searches.
- Analysis of the knowledge base users' activity with the help of the community networks contacted, and the semantic searches carried out, with the help data-mining methods.
6 REFERENCES


7 Publications related to the field of the present research


- Andor ABOYNI-TÓTH, (2006): ”The Role of Education Portals in Hungary—are teachers facing a change in methodology?”, proceedings of the ISSEP (Informatics Education – the Bridge

