5th INTERNATIONAL DOCTORAL SCHOOL ON INFORMATICS EDUCATION AND EDUCATIONAL SOFTWARE ENGINEERING RESEARCH

Traditional annual event, organized since 2010 by the
Vilnius University Institute of Mathematics and Informatics in cooperation with
Lithuanian Computer Society

Organisers:
Prof. dr. Valentina Dagienė, chair
Dr. Tatjana Jevsikova
Lina Cibulskaitė

November 26-30, 2014
Druskininkai, Lithuania

ALL PARTICIPANTS

Prof. Dr. Erik Barendsen, Radboud University Nijmegen, The Netherlands
Prof. Dr. Javier Bilbao, University of the Basque Country, Spain
Prof. Dr. Andrej Brodnik, University of Ljubljana, Slovenia
Dr. Tatjana Bulajeva, Vilnius Univerity, Lithuania
Dr. Renata Burbaitė, Panevežys gymnasium, Lithuania
Prof. Dr. Valentina Dagienė, Vilnius University, Lithuania
Dr. Tatjana Jevsikova, VU Institute of Mathematics and Informatics, Lithuania
Prof. Dr. Mattia Monga, The University of Milan, Italy
Prof. Dr. Sergey Pozdniakov, Saint Petersburg State University, Russia

Aivar Annamaa, PhD student, University of Tartu, Estonia
Lina Cibulskaitė, PhD student, Vilnius University, Lithuania
Vladimiras Dolgopolovas, PhD student, Vilnius University, Lithuania
Martin Drlík, PhD student, University of South Bohemia, Czech Republic
Silvio Giaffredo, PhD student, University of Trento, Italy
Andreas Grillenberger, PhD student, University of Erlangen-Nürnberg, Germany
Daina Gudonienė, PhD student, Vilnius University, Lithuania
Edmund Laugasson, PhD student, Tallinn University, Estonia
Mareen Przybylla, PhD student, University of Potsdam, Germany
Nataša Mori, PhD student, University of Ljubljana, Slovenia
Silver Püvi, PhD student, Tallinn University, Estonia
Airina Savickaitė, PhD student, Vilnius University, Lithuania
Dovilė Stumbrienė, PhD student, Vilnius University, Lithuania
Gabrielė Stupurienė, PhD student, VU Institute of Mathematics and Informatics, Lithuania
Willem van der Vegt, PhD student, Windesheim University for Applied Sciences, The Netherlands
Irina Vinogradova, PhD student, VU Institute of Mathematics and Informatics, Lithuania

The Fifth International Doctoral School (Doctoral Consortium) is organized by Vilnius University Institute of Mathematics and Informatics on November 26–30, 2014 in Druskininkai, Lithuania.

The aims of the Doctoral School are:

- To offer a friendly forum for doctoral students to discuss their research topics, research questions and design in the field of computing education / educational technology – informatics engineering and education.
- To receive constructive feedback from their peers and senior researchers, to help with choosing suitable methodology and strategies for research.
- To support networking with other researchers in the informatics engineering education research field.
- To discuss any relevant questions related to research and academic life.

Participants

The School is designed primarily for students who are currently enrolled in any stage of doctoral studies with a focus on informatics / informatics engineering / computing education research. Students, who are considering doctoral studies but not have yet a formal doctoral student researcher status, may participate as well.

Senior researchers in the field will provide feedback and suggestions for improvement of the research proposals.

Requirements

Each participant should submit a document, which includes the following information:

- a brief background of the applicant including information about prior studies, research topic, publications if any, and possible teaching experience;
- a summary of his/her research, including motivation, any relevant background, and main literature to contextualize the research, research questions, methodologies used or planned, and possible results obtained;
- questions related to the research that the applicant would like to discuss and get feedback on in the doctoral school.

The summary will be made available for other participants of the doctoral school to allow providing feedback and preparing questions on the research.

DOCTORAL SCHOOL AGENDA

Wednesday, November 26

15:00	*Bus from Vilnius airport*
15.30	*Bus from Vilnius bus station*
18.30	*Dinner*
20:00	*Welcome and discussion (please bring your bath suits)*

Thursday, November 27

07.30 – 09.00	*Breakfast*
09.00 – 11.00	Prof. Dr. *Andrej Brodnik* (University of Ljublana, Slovenia). Suggestions and criteria for writing computer science education doctoral thesis.
11.00 – 11.30	*Coffee break*
11.30 – 13.00	Practical work and students' presentations in two groups: research goal and tasks, research plan and research methods, etc. (preferable by using slides) *Group 1. Computing education* research (chair prof. A. Brodnik). *Group 2. Technology enhanced learning* research (chair prof. M. Monga).
13.00 – 14.00	*Lunch*
14.00 – 16.00	Student's poster presentation: your BIG research idea (5 min. for each)
16.00 – 16.30	*Coffee break*
16.30 – 18.00	Reflection on students' posters: all participants will read posters and write down their questions and comments.
19.00 – 20.00	*Dinner*
20.00 – 22.00	Late discussions in groups

Friday, November 28

07.30 – 09.00	*Breakfast*
09.00 – 11.00	Prof. Dr. *Erik Barendsen* (Nijmegen Rounbound University, The Netherlands). Investigating teacher knowledge and students' learning using PCK instruments, concept maps and learner reports.
11.00 – 11.30	*Coffee break*
11.30 – 13.00	Individual work. Improve (re-write) your poster which summarizes your research: BIG research question, goal, subtasks, data collection and analysis methods, theoretical framework, scope, and use of results
13.00 – 14.00	*Lunch*
14.00 – 16.00	Work in small groups (2-3 students with a senior researcher).
16.00 – 16.30	*Coffee break*

16.30 – 19.00 Continuation of the work in small groups.

19.00 – 20.00 *Dinner*

20.00 – 22.00 Read posters and write down your questions and comments

Saturday, November 29

07.30 – 09.00 *Breakfast*

09.00 – 11.00 Dr. *Renata Burbaitė* (Panevėžys gymnasium). Using software to make research easier

11.00 – 11.30 *Coffee break*

11.30 – 13.00 Individual work. Improve your poster again

13.00 – 14.00 *Lunch*

14.00 – 16.00 Work in small groups (with a changed senior researcher)

16.00 – 16.30 *Coffee break*

16.30 – 19.00 Final presentation of your research work and discussion (15 min. for each student)

19.00 – 20.00 *Dinner*

Sunday, November 30

07.30 – 09.00 *Breakfast*

10.30 *Departure to Vilnius airport*

Evaluating different automatic feedback policies for programming assignments

Aivar Annamaa

De facto 6th year PhD student, *de jure* expelled PhD student
University of Tartu, Institute of Computer Science
Liivi 2
Tartu 50703, Estonia
aivar.annamaa@ut.ee

Research area description

An automatic assessment system for programming assignments is a piece of software which is able to assess correctness or other properties of programs written by students. Usually the students can submit the program by themselves. The number of resubmissions allowed and the nature of the feedback given to students can vary. The feedback given can be complemented with human feedback. Educators are interested in these systems, because they believe these can make teaching and learning more effective by relieving teachers from tedious parts of evaluating students' work and by providing fast feedback to students.

Most of the scientific literature about automatic assessment describes the features of and experiences with some specific system or approach [1]. Therefore it is not easy to compare the effects of different approaches. There is at least one paper describing results of different aproaches (more specifically, different resubmission policies) used in similar environment [3], but more studies like that are needed to understand the field better.

Although automatic assessment is a busy field, there are many questions that could be asked from data collected by suitably designed systems, and not all of these questions are studied thoroughly (or at all). For example:

- Does different tone in automatic feedback affect the student? Eg is it worth trying to make the comments encouraging?
- How does the effect of strict automatic tests (eg. an extra space in output means the test is failed) compare to the effect of flexible tests (trying to make sense of student's work even if it doesn't conform to specification or if specification is fuzzy)?
- Do automatic assessment reduce students creativity and initiative for doing extra work? How to find the good balance between automatically testable assignments and open ended assignments?
- How does the effect of detailed feedback („Your function gives incorrect answer with empty list") compare to effect of vague feedback („Your function failed one test")

Last, but not least, most effort so far has been focused on assessing the result of a programming session, but analyzing the process of the programming could be even more rewarding. For example, we could cluster students according to their apparent approach and goals like in [2] but by using much more granular data based on program development events, up to the level of different keystrokes. There are tools for collecting detailed logs from programming sessions and papers presenting analyses of such logs [4], but I haven't heard anybody trying to integrate process analysis into student-accessible automatic feedback systems.

I want to compare the effect of different approaches by dividing a cohort of students into different groups and assigning different submission and/or feedback policy to each group. Besides automatic analysis of submitted program text, I want to implement some analyses and give automatic feedback on event data collected while student was developing the program.

A presentation of any preliminary ideas, the proposed approach and achieved results

At the moment I'm teaching programming courses in Institute of Computer Science, University of Tartu. For last 4 years my main focus has been on introductory programming course meant for CS, math, physics and IT students. It is attended by about 300 students each year who are divided into 16 lab groups. The course is taught with Python. This course will be the main context of my research.

For the needs of this course I have developed a web-based textbook (https://programmeerimine.cs.ut.ee/, has been in use for 3 years) and a Python IDE, Thonny (http://thonny.cs.ut.ee/, is able to log detailed information about programming process, has been used by some students since this October). We use Moodle for managing grades and programming assignments. Starting this year, students can get automatic feedback for most of their homework assignments. For this we are using Virtual Programming Lab (VPL) plug-in for Moodle (http://vpl.dis.ulpgc.es).

The plan for this semester is to study the data collected by VPL and Thonny, in order to formulate more precise research questions for next year. More specifically, I want to see how the number of resubmissions per assignment and number of program runs during development correlates with student's final grade.

Next year I want to divide students into different groups and modify VPL to use different submission and feedback policies for different groups. At the moment I have following groups in mind:

- Unlimited number of resubmissions, detailed feedback
- Limited number of resubmissions, detailed feedback
- Unlimited number of resubmissions, vague feedback

In order to avoid some students protesting about being assigned to a specific group, I plan to use only volunteers in the experiment and offer some extra credit to them. Also, I plan to enhance Thonny to allow submit the solution together with event logs right from the IDE.

This year I can correlate the number of resubmissions with the grade in the situation when student is free to choose how many times he submits. Next year I want to see the effect of forced restriction of the attempts. My hypothesis is that the restriction guides motivated students to think more thoroughly about the problem and their solution, and therefore gains them better grades. At the same time I'm worried that the restriction may tempt unmotivated students to give up more easily or resort to plagiarism.

Later I plan to experiment with automatic feedback on programming process (eg. „You tend to write rather long blocks of code without testing your program, that's why you spend so much time on debugging. Try testing your program more often!").

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4. Yoon (2012). An exploratory study of backtracking strategies used by developers. *Cooperative and Human Aspects of Software Engineering (CHASE), 2012 5th International Workshop*

Expectations and motivation to attend Doctoral School

I want to get advice and feedback for my ideas and get new ideas from other participants.

Researh of tests generation and validation for informatics education

Lina Cibulskaitė

1st year PhD student
Vilnius University Institute of Mathematics and Informatics
Akademijos 4
Vilnius, LT-8663, Lithuania
lina.cibulskaite@mii.stud.vu.lt

Research area description

The main problem is to evaluate tests of informatics education, what skills can be assessed.

The aim of research is to analyze specific of tests generation for various computer programs and prepare methods and tools for test validation.

Research questions:

1. How to evaluate the validity of the test instrument?
2. What technologies and software are used for educational test?
3. What methods are used to assess the value of the test?
4. What is the current status of test generation and validation in informatics education?

An outline of the current knowledge of the problem domain.

Educational programs are designed to develop student‘s ability. The main problem of that is the correct assessment of the knowledge. Testing is one of the most popular ways to evaluate knowledge. Also Organization like the Test Commission emphasize the importance of validity [1]. Different methods of tests generation are being used [3]. Item Response Theory (IRT) are used in Computerized Adaptive Tests as a modern mental test theory [4]. ‘IRT works when there is a need to determine a student’s level of knowledge, but not measuring the student’s knowledge in every concept or level in the course’. For example, in the article ‘Measuring Student Competences…’ are mentioned that ‘the main goal of IRT analysis is the estimation of two parameters: the item difficulty … and person parameters’ [5]. So, the task is to find effective method for validity of the test. Some tools exist. Test generation system uses the ontology ‘to memorize pieces of knowledge of application’ or has been used as a persistent level by test system [2]. However, the existing tools and models required attention.

Advances beyond the state-of-the-art in terms of your specific contribution and research plan (A description of the Ph.D. project's contribution to the problem solution).

That problem is actual for science of education and computer.

A presentation of any preliminary ideas, the proposed approach and achieved results

I am in the beginning of my research. At the moment I am analyzing scientific literature and collecting the data about educational test generation, problems of informatics test generation and validation, items response theory, requirements for testing, software for testing.

The next step is to indicate the main problematic, test classification and ontology, create the model of tests generation and validation.

The task is offering a way to construct a meaningful model for tests generation and validation.

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Expectations and motivation to attend Doctoral School

I expect to get practical advices from the invited participants of the consortium. Also it is the opportunity to discuss about my topic and research methods and formulate correct main task.

Design and development of constructivists learning objects for theoretical computer science and scientific computing education.

Vladimiras Dolgopolovas

2 year doctoral student
VU Institute of Mathematics and Informatics,
Informatics methodology department
Akademijos g. 4
LT-08663 Vilnius, Lithuania
vdolgopolovas@gmail.com
Supervisor prof. Valentina Dagienė

Background and research area description

This is an interdisciplinary research which focuses on applications of constructivists teaching and learning theories and methods to theoretical computer science, scientific computing and computer algebra education. All of the above-mentioned educational disciplines could be considered as a part of an advanced computer science (CS) education curriculum, thus motivating the researcher's efforts looking for a common approach, methods and constructing a unifying educational framework which is intended to be based on constructivist learning and teaching paradigms.

Theoretical computer science education is considered as one of the important part of an advanced CS education. Here we consider fundamental results presented by Juraj Hromkovič as a background for further studies and the research topic development. "Theoretical computer science is a fascinating scientific discipline. Through its spectacular results and high interdisciplinarity, it has made great contributions to our view of the world. However, theoretical computer science is not the favorite subject of students, as statistics would confirm. Many students even view theoretical computer science as a hurdle that one has to overcome in order to graduate. There are several reasons for this widespread opinion. One reason is that amongst all areas of computer science, theoretical computer science is the mathematically most demanding part and hence the lectures on theoretical fundamentals belong to the hardest courses in computer science. Not to forget, many computer science students start their study with a wrong impression of computer science, and many lecturers of theoretical computer science do not present their courses in a sufficiently attractive way. Excessive pressure for precise representation of the minute technical details of mathematical proofs plus a lack of motivation, a lack of relevance, a lack of informal development of ideas within the proper framework and a lack of direct implementation and usage, can ruin the image of any fascinating field of science." **[1]**

Scientific computing as well as theoretical computer science needs to be considered as one of the most important disciplines for advanced CS education. As a background for our research we consider an approach developed by G. E. Karniadakis and R. M. Kyrby. The authors offer a

seamless approach to numerical algorithms, modern programming techniques, and parallel computing. “Often times such concepts and tools are taught *serially* across different courses and different textbooks, and hence the interconnection between them is not immediately apparent. The necessity of integrating concepts and tools usually comes after such courses are concluded, e.g. during a first job or a thesis project, thus forcing the student to synthesize what is perceived to be three *independent subfields* into one in order to produce a solution. Although this process is undoubtedly valuable, it is time consuming and in many cases it may not lead to an effective combination of concepts and tools. Moreover, from the pedagogical point of view, the integrated seamless approach can stimulate the student simultaneously through the eyes of multiple disciplines, thus leading to enhanced understanding of subjects in scientific computing” [**2**]. Figure 1 presents the definition of scientific computing as an intersection of Numerical Mathematics, Computer Science and Modeling [**2]**.

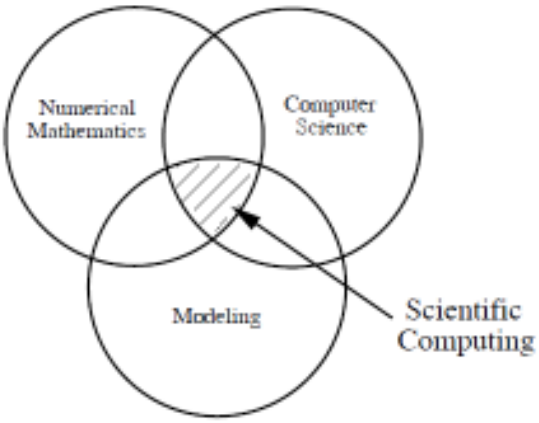

Figure 1. Scientific computing.

We consider **symbolic computations** (also named as computer algebra) as one of the important parts for advanced CS education. Although symbolic computations and scientific computing are generally considered as distinct fields, there is a strong relation among these scientific areas of study, especially from the point of view of educators. There is a solid computer algebra educational background developed and promoted by the Waterloo university symbolic computational group. Headed by prof. George Labahn, the group researchers are among the leading experts in the field [**3**].

Constructivist learning could be considered as a main source of solutions for constructing of the relevant learning objects. R. N. Caine and G. Caine in their fundamental research **[4]** propose the main principles of constructivist learning. One of the most important for us is as follows: "The brain processes parts and wholes simultaneously". So, a well-organized learning process provides details as well as underlying ideas. Using Model - Centered learning, we introduce the goal of the research

after constructing a model for simulation. That allows us to observe the results and to draw relevant conclusions.

A presentation of any preliminary ideas, the proposed approach and achieved results
We propose a **model centered approach** for the purpose of constructing of the relevant learning objects and educational frameworks. The model centered approach was introduced by A. S. Gibbons as Model - Centered Instruction in 2001 **[5]**. For us the following main principles are important:

- Learner's *experience* is obtained by interacting with models;

- Learner solves scientific and engineering *problems* using simulation on models;

- Problems are presented in a constructed *sequence*;

- Specific instructional *goals* are specified;

- All necessary *information* within a solution environment is provided.

M. Millard, J.M. Spector and P.I. Davidsen **[6]** propose Model Facilitated Learning using "interactive simulations". The authors present a modern computer technology powered by "promising methodology" based on "system dynamics". "Supportable experiences include the construction of interactive … models as well as their use *for hypothesis testing and experimentation*".

R. Lehrer and L. Schauble **[7]** refer to the experiments with different representations of the model: "Student learning is enhanced when students have multiple opportunities to invent and revise models and then to compare the explanatory adequacy of different models".

In the filed **scientific computing education** an approach of experiments with models is proposed by L. Xue et al. [**8**]. Authors introduce "teaching reform ideas in the "scientific computing" education by means of modeling and simulation". Authors also suggest "…the use of the modeling and simulation to deal with the actual problem of programming, simulating, data analyzing…". Model-Centered Learning is used in mathematics education. Plenty of models are constructed using "Geogebra" software [**9**]. Models play a central role in Science Education [**10**], [**11**].

As an example of the possible solution, we introduce an application of the model centered approach to the field of scientific computing education [**12**]. Such approach incorporate the constructivist learning ideas and also could be used as a platform for novice learning methodologies such as inverted leaning or lab based learning [**13**]. The main approach is presented in Figure 2. The set of programming models is proposed. The methodology is based on stochastic simulation of the provided model of the multiphase queueing system [**14**].

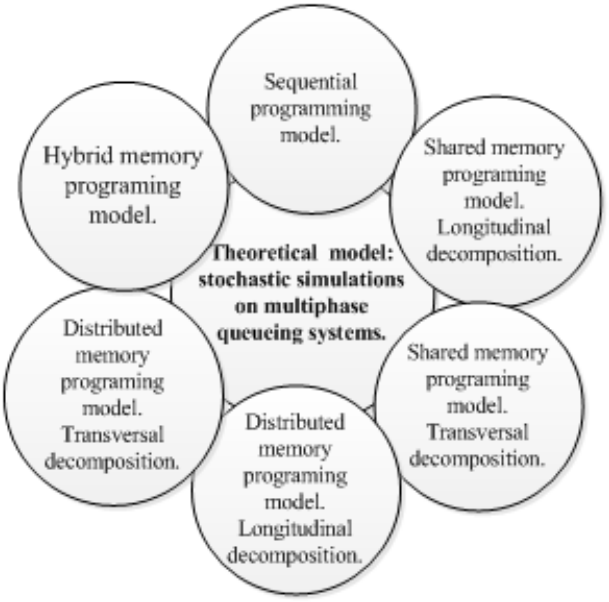

Figure 2. Model centered approach

At the present time the next **research questions** are considered to be solved:

- What is the set of topics, methods, theoretical constructions and algorithms to be included in to the educational framework?

- In which way the relevant learning objects should be constructed?

- What are the basic requirements for the learner's background?

- What are the key instruments for modeling and experiments with models?

- What is the methodology of evaluation and testing?

The present task of the research is to investigate the theoretical computer science, scientific computing and symbolic computation algorithms and theoretical constructions. This will provide a basis for further developing of the methodology and constructivists learning objects based on computer mathematics models. **An overall research goal** could be described as follows. As a result of the research the proper learning framework and learning objects should be developed. The models of the main advanced programming constructions like parallel calculations, declarative programming and others which are based on constructivist learning approach must be designed. Under such approach the basic mathematical constructions are introduced in parallel with programming models. The next step is conducting of experiments with computer mathematics models, verifying theoretical mathematical results. This improves computer science and mathematical literacy. This is also provides an introduction for basic mathematical topics of various difficulty levels.

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Expectations and motivation to attend Doctoral School

Expectations include the next ongoing research topics to be clarified with an assistance of thesis supervisor and invited researchers:

- the research methodology is needed to be clarified
- the field of the research is possibly needed to be narrowed
- the background theories are needed to be systemized

- the experimental activities should be clarified

Social networks in informal education

Martin Drlík

2nd year of doctoral studies
University of South Bohemia
Jeronýmova 10
České Budějovice, 371 15, Czech Republic
martin.drlik@email.cz

The work focuses on the social networks in education, specifically in informal education. We know that social networks have educational potential. But it is necessary to find out what benefits they can bring to learning, how to effectively use and integrate them into the educational process. We will be observing user interactions, sharing of information, and the impact to their studying performance.

One of the core concepts is social interaction, which plays essential role in the development and knowledge. Vygotsky in his work attempts to explain that consciousness is the final product of socialization. He states that learning takes place primarily on social and subsequently the individual level. In the context of social interaction is mentioned zone of proximal development (ZPD), which provides an effective way to develop skills in interacting with peers (or under the supervision of an adult). Vygotsky's concept of ZPD is in accordance with the social networks that provide this interaction.

Research in the field of social networking services and the possibility of sharing have been in progres for many decades. New technologies have appeared simultaneously with its influence on teaching and learning (Learning 2.0). The three main learning theories (behaviorism, cognitivism and constructivism) were enriched by connectivism. Siemens, which introduced this concept, examined how formal and informal learning intersect. Informal learning is an aspect of learning by experiences.

Siemens and Downes in their work mention the issue of educational networks and connected knowledge. They claim that learning is based on cooperation and collaborative activities – the ability to create groups. Downes introduces the concept of Personal Learning Environment (PLE) – educational resources should not be only consumed, but also produced. The key is the ability to determine the value of information and make connections between sources of information.

In the context of social networks Deng emphasizes that online participation correlates with the study performance. Social network offers access from anywhere and anytime. The combination of online participation, immediate feedback and sharing posibilities make them potentially important educational tool.

Research area description

Pedagogical theories and researches confirm the importance of social interaction and social interconnection. Social networks are becoming a steady tool with potential educational value. The main problem is how to effectively use these tools (such as Facebook) for education. When and when not these tools bring effective results and better study performance and why that is so. We think that solving of this issue is relevant in the context of informal education, because social networks are primarily designed for leisure activities. From the results of the research we can then conclude and answer the above questions. If we can elucidate this issue, it will be easier to understand how students use social networking to education in their free time and we will be able to effectively integrate them into the learning process.

The aim of research is to analyze the behavior of users (students) on social networks, in order to understand how often is this tool used in the context of education. The study group on the Facebook social networking site will be especially explored. We want to encode any communication in the group during a specific period of time and further investigate these encoded data. The subject of research will also be semi-structured (or unstructured) interviews with students.

Current research is dealing with problems of social networks mainly in the context of classical teaching. They are compared with e-learning tools such as Moodle (the possibility of interaction). The motivations and experiences of students in online communities are studied. Knowledge and cognitive processes in project-based online discussions via social networks are analyzed. The potential educational value of Facebook is verified. Discussed are also topics related to the usage of mobile devices in learning and even the use of Facebook impacts during implementation into the curriculum. There appear topics, how students perceive the social network, what experience they have when sharing school information. Investigated is the relationship between the frequency of Facebook usage, participation in Facebook activities, and student engagement in these activities.

The issue of social networks in informal education is very current. However most researches are not focused in this area. Facebook is not primarily intended for teaching, it is important to examine its processes mainly in relation to education in informal learning communities. A problem with the relevance and validation of the data may occure – of course it is necessary that the tutor is not a part of the group and thus not discort the topics solved within the group. If we understand how students use social networks in informal learning, we will be able to implement the educational process more easily and efficiently, where it can be beneficial.

A presentation of any preliminary ideas, the proposed approach and achieved results

There are some preliminary ideas on how to better examine the issue of social networks. We need to penetrate into community life using these tools but we must not influence it. It seems useful to

look at the issue from multiple views – such as social networks (Yammer) are successfully used in large companies – what is the reason for their implementation, what is their purpose, are they effective for the company? Some key features of social networks may be common for different types of usage. It also brings us opportunities to implement social networks (eXo) directly into the school servers, as it is the case of Moodle. One of the basic problems of implementation of Facebook into schools is its licensing policy and the fact that all data are owned by the third parties. Social networks have the potential educational value, as shown in research studies based on B. S. Jong. We carried out a similar survey in the Czech Republic, which confirms the results of the study. As shown in Table 1, the most popular social network is Facebook.

Table 1. The most often used social networks

Social network	Use
Facebook	88 %
Google+	15 %
Twitter	12 %

But there are also problems with browsing throught past articles on Facebook. The concept of a "timeline" is insufficient, as shown in Figure 1.

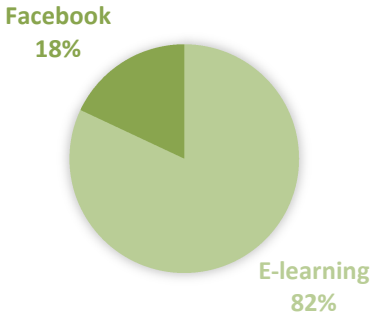

Figure 1. Preferred platform for reviewing or browsing through past articles

One of the most important benefits of social networks is the possibility of interaction. Figure 2 shows a preference for interaction in the course.

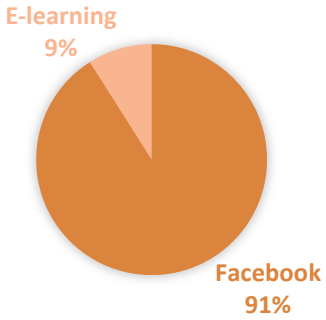

Figure 2. User preferences for course interaction

Although Facebook is representative of informal education, it is confirmed that 87 % of respondents discussed topics related to learning on the social networks, see Figure 3.

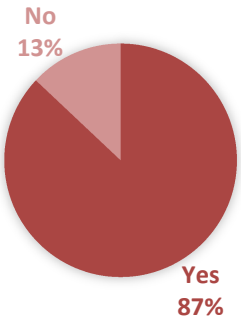

Figure 3. Have you discussed the topics related to education on facebook?

Research also points out that 62 % of respondents participating on social network does not have lecturer as a friend. Users do not want to have a tutor in a study group!

A sketch of the applied research methodology (data collection and analyzing methods) is following:

- Quantitative methods (introduction to the topic – online questionnaire study by B. S. Jong) – verify whether it makes sense to do research in this area.
- Qualitative methods – acquisition, coding and analysis of data from the closed Facebook study groups.
- Quantitative-qualitative research – semi-structured (or unstructured) interviews in combination with coding and data analysis.

We expect that research will demonstrate the educational value of Facebook in informal learning and discovery of key processes contributing to the better study performance. It is very probable that the activity in Facebook study groups will rise during exams.

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Expectations and motivation to attend Doctoral School

Doctoral School provides an opportunity to discuss the research topic, research questions and design. I expect a feedback and comments from senior researchers and students on the work so that I could create a quality concept of research and the entire work. The main motivation is to improve the theme concept and its correct orientation. It is a rewarding experience, an opportunity to make new contacts and expand my knowledge in other research areas, learn about new research methods and prepare for similar scientific consortiums.

Computer Science Competences in Secondary Schools

Silvio Giaffredo

First Year of doctoral studies
Department of Information Engineering and Computer Science (DISI) - University of Trento
v. Sommarive, 9
Trento, 38123, ITALY
silvio.giaffredo@unitn.it

Research area description

- (***main problem ... and its relevance***) My research area is the Computer Science Education by Competence, in secondary schools. The competence approach seems to be not so much applied in real classes and in different disciplines, in spite of the general dispositions by Educational authorities. The distance between the declaration of intent and the real situation has many negative consequences. One is that it is much more difficult to compare the learning outcomes of different educational activities, due to lack of standards.
- (***aim of research***) The aim of research is to develop a support [4] to help teachers in applying the competence model, not for duty but as a sound reference, which can be useful in their daily activities. The domain of the research is limited to the local area of Trentino province, and to the computer science education in the secondary schools.
- (***solutions' state-of-the-art***) The European Institutions have defined a set of common competences for European citizens [1] at the first level of mandatory education, also called key competences. But for subject-specific competences, a detailed and commonly accepted definition has not yet been given by the institutions, for the context of the formal education. In the different context of professional habits, a standard definition of competence has been reached, with the European e-Competence Framework (e-CF, see [2]). The educational and professional contexts can be kept separated or, on the contrary, an integration can be pursued: as a consequence of this choice, different solutions are proposed. In the case of integration of the professional framework in the secondary school, some competences can be included in the ordinary curriculum, whereas others must be reserved only to few pupils, on a voluntary basis. On the other hand, ignoring the existing framework don't means to build a competence model from scratch, because usually the educational systems propose a national reference. Related to the specific situation of the country, the level of detail can offer different national standards of reference, useful in supporting the phases of learning activities. For example, the MoKoM project [3], developed in Germany, is introducing the measure of the competences, offering a complete set of references, from learning design to the assessment phase.

- (***your specific contribution and research plan***) The research will try to develop a taxonomy of competences, contents, tools and methods, which could be used in Informatics classes of the secondary schools of Trentino. The taxonomy will be build up from an initial set of definition of competences and contents, derived partially by institutional terms, and partially by the field of the computer science education research. The first release of the taxonomy will be submitted to the evaluation of a group of teachers in our province schools, with the aim at tuning gradually a final version of the taxonomy, fitting the specific needs of different kind of schools and learners of our local area. A software application will be support the introduction of the taxonomy in the daily activity, hosting a collection of examples and good practices which will grow up with the evolution of the research and the collaboration of involved teachers.

A presentation of any preliminary ideas, the proposed approach and achieved results

- Currently, I'm working on the first definition of the research plan - the research proposal - which will be the main subject of my forthcoming qualifying exam.
- In the first turn with the school teachers, a revision of a minimum set of competences will be produced. The teachers will be invite to compare the proposed competences to their daily work, helping in linking their working methods and tools to the proposed set. ***A sketch of the applied research methodology (data collection and analyzing methods)***
- The minimum goal of the research is to share the proposal model among a wide number of teachers, at least half of the Informatics teachers of the province, including all non-vocational upper secondary schools. The number of revision of the initial taxonomy will indicate the level of participation of the involved teachers. In the subsequent phase, the number of teachers accepting the partial results of the first taxonomy revision will say the meaningfulness of the revision work. ***Expected achievements and possible evaluation metrics to establish the level of success of your results***

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Expectations and motivation to attend Doctoral School

I really would like to extend the border of my community, and meeting researchers interested on the Informatics education is a great opportunity. At the moment, the educational level of interest in my study is the secondary school, but I think that extension to different levels might also be of interest. Moreover, I'd specially appreciate to get new ideas related to the education by competence and to the measurement of competence levels. Lastly, I'm looking to get feedback on my research ideas.

Data Management in Secondary Computing Education

Andreas Grillenberger

PhD student since November 2013
Friedrich-Alexander-Universität Erlangen-Nürnberg
Martensstraße 3
91058 Erlangen, Germany
andreas.grillenberger@fau.de

Research area

Topics like Big Data, NoSQL, Data Analysis and so on are dominating in CS research and practice in the last years. Additionally, for example in news and media, people encounter various data management terms today and need various competencies for handling all the data they generate continuously. In contrast, current computing education mainly emphasizes the storage of well-structured data in mainly relational databases while important aspects like Data Privacy or Data Security are only mentioned marginally.

In a research paper [3] at this year's ISSEP, we described these current developments and important challenges that are arising for CS education in this context:

- discussing the relevance of database concepts
- involving Big Data examples into teaching
- teaching data analysis for understanding data mining
- changes in the relevance of data modeling
- sharpening the view on data privacy

Especially, the current focus on databases is challenged, as in CS research and practice various aspects of this large field *Data Management* (which also includes databases) are re-evaluated in this new context. For example, avoiding redundancy in order to ensure consistent data is an important aspect when using relational databases. On the other hand, redundancy is also being used intentionally for ensuring a high availability of and fast access to data. Also in the daily life, people encounter an important use of redundancy daily – data backup. In contrast, schools typically emphasize preventing redundancy instead. As an important criterion for topics in general computing education is, that aspects considered in teaching should be long-lasting principles (cf. [5], [7]), in this context it seems promising to check how these developments affect the current focus of and topics in CS education.

In another recent work [1], we analyzed several educational standards and curricula from several countries on the aspects of data management that are covered. The results of this study confirmed our presumptions: current *database education* mainly concentrates on storing data in mainly relational databases and on using SQL. Aspects like data security and privacy as well as the social,

legal and ethical implications are considered marginally. On the other hand, data analysis, backup and recovery, cloud storage, distributed data storage and so on are hardly mentioned at all. Also, only one of the 12 analyzed documents covers the topic *meta-data*. In contrast, this topic is an important aspect of current discussions on surveillance by intelligence agencies, but people often do not realize that they are also affected. As we compared this representation of topics in current CS education to a characterization of data management from a professional view [6], we found that there is a clear gap between current teaching and the research in this field. While the professional characterization of data management also covers all the aspects of current CS education in this field, most of the aspects of data management are not part of current teaching so far. An overview of the results of this study is shown in Diagram 1.

Research Situation

As usual in Germany, my doctoral study is not part of a PhD program; instead, it is an individual part-time study alongside a (full-time) employment. My supervisor is Prof. Dr. Ralf Romeike, head of the Computing Education Research Group at the University of Erlangen-Nürnberg. I was external part-time PhD student at this group from November 2013 until September 2014, since October 2014 I am working as full-time research assistant.

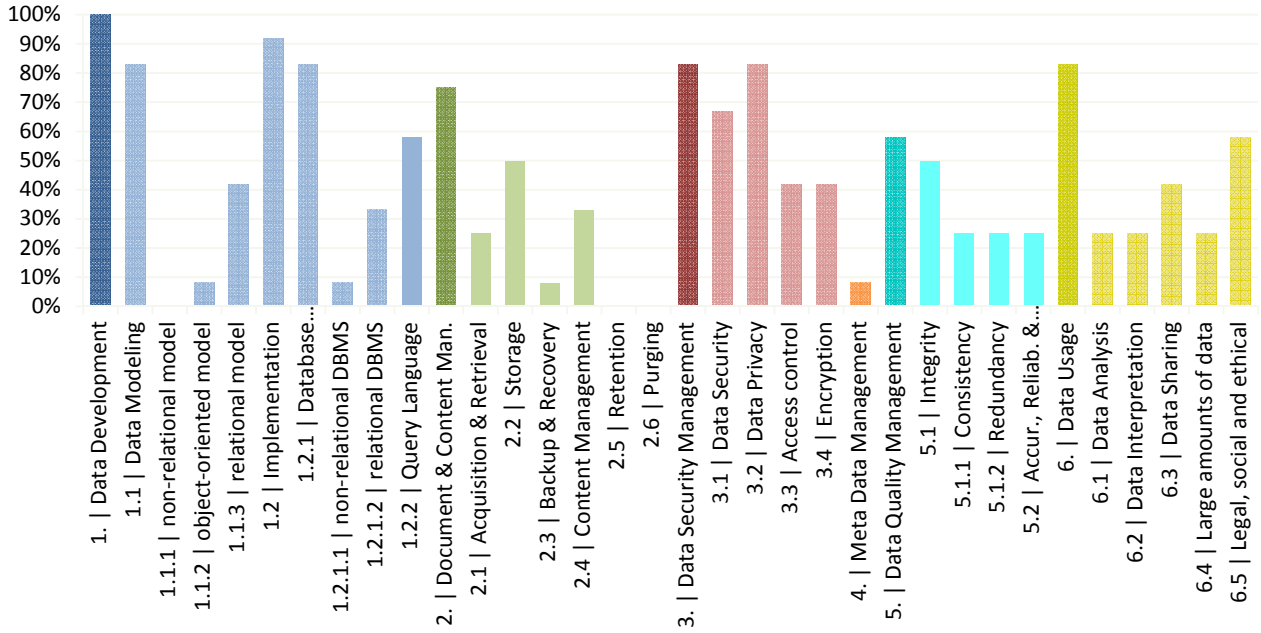

Diagram 1: Results of our study on the representation of Data Management in current secondary CS education. The darker bars represent the top-level categories which were coded always when one of its subcategories (same color) was coded.

Literature Review

As described in our publications, data management was an important topic in CS education research at last in the early 1990s when databases were introduced into teaching. Also in CS

research and practice, relational databases were dominating this field for years, but today there are various developments. The number of publications on data management is increasing continuously in the last years, so that data management is becoming as important as algorithms today. In contrast, CS education research in this field mainly concentrates on simplifying and subsequently improving teaching of the proven topics *relational databases* and *SQL*. So far, there were no research publications on the implications of these modern topics on teaching.

Research Question and Goals

This shortage of current literature on *data* and *data management* in CS education shows that this topic is only considered marginally at the moment. In order to meet the current relevance of *Data Management* in CS research and practice, the question guiding my research is:

Which are the influences of current developments in data management on secondary computing education and how can CS education handle the newly arising requirements in this field?

Answering this question not only includes a broader view on the topic *data* in current CS education, but also answering the following sub-questions:

1. Which are the fundamental and long-lasting aspects of data management that are important for computing education?
2. What knowledge and skills does everyone need to have concerning data management?
3. Which pre-knowledge, attitudes and perceptions do learners currently have on this topic as well as on the chances and threats of data management?

Preliminary Ideas / Approach

As described before, as first step for answering question 1, we analyzed current educational documents to find out how data management is represented in these [1]. Therefore, we did a qualitative content analysis as described by Mayring [8].

Steps planned for the future are:

1. Expert interviews (for questions 1 & 2)
2. Questionnaire studies (for questions 2 & 3)
3. Providing learning material (e.g. examples for bringing data analysis and visualization to school, checklists on topics like “How can I secure my data?” that can be used as learning materials, …)

Results to Date

We currently achieved the following results that were also published as conference papers:

1. We described a set of key competencies [4] concerning different aspects of data management that everyone needs today. By this, we also described the strong relation between data management and daily life.
2. We discussed which major challenges for secondary computing education are arising from the previously described developments in CS research on data management [2].
3. In a poster abstract [3], we described three main aspects of the motivation of this work: the ongoing paradigm change in data management science, the relevance of data management for daily life and the importance of data management as well as using data analysis as tool in various contexts and data-driven applications.
4. In a study [1], we analyzed the representation of data management in current CS education curricula and educational standards. Additionally, we compared it to a professional characterization of data management in order to describe the gap between current research in this field and what is currently done in schools in the context of databases.

Expected Contributions

The described research aims on analyzing one of the current main topics in CS research and practice – *data* – on its implications for secondary computing education. This not only prepares including the fundamental and long-lasting aspects of this topic into further CS education curricula, but also aims on providing students a better understanding of current developments and on enabling them to handle their data in daily life in a proper and responsible way.

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The Architectural Learning Objects Model for Massive Open Online Courses Design Using Semantic Web Technologies

Daina Gudoniene

1st year of doctoral studies
Vilnius University
Akademijos str. 4
Vilnius, LT-08663, Lithuania
daina.gudoniene@gmail.com

Research area description

Interactive educational objects development by using new technologies is critical mass for massive open online courses development and delivery. Dealing with issues how to develop the interactive lessons (learning objects) as adaptive, personalized, motivating, relevant content expressed, easily be created, exported in various formats, and etc. What is the application of interactive classroom teaching advantages and problems, what templates can be developed and provided for courses designers? The massive form of studies refers to us that the number of students is not limited. Studies are open, which means that the use of open source tools and measures a variety of open sources of information are open and can be used by any connected users and it is very important looking to the quality of studies. To assure the successful study process there is necessary to develop an architectural model of interactive learning objects development and delivery for massive open online courses by using semantic web technologies and techniques. Well selected tools and environments will assure the quality of education process.

Looking to the analysis on learning objects implementation into practice that was organized in 2014, we can see that single learning objects were analysed, but have not been analysed the architectural models of learning objects design for massive open online courses having relations with semantic technologies and improving the quality of study process. There is missed a research in this area and estimates, recommendations, and specific examples of realization, science literature is rich in data on research related with individual learning objects for learners. However, there is still the question of how to assess that that learning objects with the learning activities are well constructed, technologies and technological solution well selected.

The aim of the research is to explore the possibilities of interactive learning objects, problems, perspectives and to develop learning objects templates and an architectural model for massive open online courses development and delivery by using semantic web technologies.

Tasks:

1. To explore the application of interactive learning objects for massive open online courses, and their usability with international practice and existing technologies.
2. To perform modern training facilities and the semantic web technology overview.
3. To conduct analysis of existing interactive learning objects and the provision of architectural models.
4. To create an architectural model of interactive learning objects for massive open online courses development and delivery.
5. To experiment with the architectural model impact on study process design.
6. To expertise and evaluate the performed interactive learning objects architectural model.
7. To summarizes the theoretical and empirical research results, essential results and draw conclusions.

The expected outcome. Created interactive learning objects architectural model for massive open online courses using semantic web technologies.

A presentation of any preliminary ideas, the proposed approach and achieved results

1. International and national scientific research data analysis.
1.1. Data analysis on interactive learning objects and semantic technologies.
1.2. Data analysis on existing architectural models for interactive learning objects design and delivery.
2. Theoretical research.
2.1. An architectural model of learning objects design for massive open online courses development and delivery.
2.2. The analysis of developed architectural model and its influence on learning objects design.
3. Empirical research.
3.1. Expertise on the developed interactive learning objects architectural model.
4. Data analysis, description and conclusions.
4.1. Theoretical research description and conclusions.
4.2. Empirical research description and conclusions.
4.3. Description and conclusions on the essential developed results.

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Expectations and motivation to attend Doctoral School

There is a big interest to meet professors from other countries and institutions working in eLearning field, providing trainings by using massive open online courses delivery model.

As well as there is and interest to meet colleagues and to share the good practice examples on the practical implementation of the research. Thanks for organizers that we have a possibility to meet each other and to work in team.

Free software strategies of managing information and communication technology infrastructure in Estonia

Edmund Laugasson

Year of your doctoral studies: 3
Your Affiliation
Tallinn University, Institute of Informatics, Narva Road 25, 10120 Tallinn, Estonia
edmund.laugasson@gmail.com
GSM: +372 52 80 479
http://www.tlu.ee/en/institute-of-informatics

Research area description

Main problem

The main problem you are trying to tackle and its relevance

How to find an academically argumented way to approach politicians, decisionmakers. Based on 2012 made research there is known expectation toward decisionmakers to make sustainable decisions for future.
Finally find the appropriate methodology and strategy to compile the dissertation.

Aim

The aim of my PhD thesis is to investigate and describe free software strategies to implement efficient, cost effective and secure information and communication technology management at state level in Estonia.

Outline of the current knowledge

An outline of the current knowledge of the problem domain (What is the state-of-the-art in relation to existing solutions to the problem)

In the European Interoperability Framework (EIF) introduction there is mentioned, that the Framework would be based on open standards and encourage the use of open source software (EIF, 2004, p. 5, p. 9, p. 24). Around the world, free software is already quite popular (Laugasson, 2010). In Europe are OpenDocument file formats also quietly spreading[1]

There is also European Framework Programme 8, which is called Horizon 2020[2] now. In the document Proposal for a Regulation of the European Parliament and Council establishing Horizon

[1] http://www.eionet.europa.eu/software/opendocument , http://www.odf-eag.eu/

[2] http://ec.europa.eu/research/horizon2020/

2020 - the Framework Programme for Research and Innovation (2014-2020)[3] there is requirement (p. 44), that at 2020 should European ICT market share one third part of world's market. It would be shame if this will be mostly achieved by purchasing proprietary software licenses and not by real research, innovation, development. These goals (major activity lines at p. 45-46) can be much more efficiently and economically achieved by using free software – then there remains much more money for real research, innovation, development and also staff knowledge will be better improved.

Information and communication technology (ICT) is top priority also at the document Proposal for a Council Decision establishing the Specific Programme implementing Horizon 2020[4] (p. 10).

The current situation in Estonia includes mostly proprietary software and its based solutions. Institutions are mostly using Microsoft, Adobe, Corel and other proprietary companies software and its data formats. Even educational software are often requiring Microsoft Windows operating system, which is not free. Public sector in Estonia is spending approximately 2,24 million € per year for proprietary office suite procuring. Estimated overall sum might be twice more. Therefore Estonia is depending too much on proprietary software and its data formats, which are not cost effective and have security weaknesses. Also software piracy is still a problem in Estonian and also rest of societies in the world (Hinnosaar, 2003).

In Estonia (and also other countries in the world) there is interoperability framework, which tells among other things about using open formats and preferring FOSS is must be policy in procuring software to state. But Estonian government has insufficient strategies to implement FOSS usage efficiently. Therefore there is a need to study and evaluate FOSS strategies and its usage at any level to achieve efficient and cost effective ICT management at the state level with also security in mind.

In the Estonian Interoperability Framework (2011), which is created using European Interoperability Framework in mind, is written: „*In the context of the framework, openness means that public sector takes into consideration the alternatives of open specifications, standards and software. When developing or ordering software, public sector should use the development methods of free software*“ (p. 11). When procuring software, free software alternatives MUST be taken into account (p. 11). When founding information systems and in public procurements' tender offers, alongside proprietary solutions, free software alternatives MUST be taken into consideration. Decision MAY be made in favour of free software, proprietary software or a combined solution, but in case other conditions are equal, software with a source code is preferred. Each case is decided on an individual basis (p. 35).

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[3] http://ec.europa.eu/research/horizon2020/pdf/proposals/proposal_for_a_regulation_of_the_european_parliament_and_of_the_council_establishing_horizon_2020_-_the_framework_programme_for_research_and_innovation_(2014-2020).pdf#view=fit&pagemode=none

[4] http://ec.europa.eu/research/horizon2020/pdf/proposals/proposal_for_a_council_decision_establishing_the_specific_programme_implementing_horizon_2020_-_the_framework_programme_for_research_and_innovation_(2014-2020).pdf#view=fit&pagemode=none

Advances

Advances beyond the state-of-the-art in terms of your specific contribution and research plan (A description of the Ph.D. project's contribution to the problem solution)

Using different technology acceptance models there is a plan to assess scenarios of different ways to deploy free software at governmental level (public sector)

Research questions and hypothesis

According the described situations above there is main topic to create for state survival and practical guide based on free software strategies. Currently in Estonia there are five state procurements at free software field but state has no good idea, how to enforce them. Also there are security issues need to be solved – malware is influencing mostly proprietary software and therefore putting in danger also mission critical data at state level.

Research questions are:

- how to change state staff working environment from using only proprietary software to use free software as much as possible
- how to increase people awareness about free software and its security, compatibility, benefit
- how to establish the usage of OpenDocument and Portable Document Format (PDF) at state level mentioned at State IT Architecture v1.01 (2007)
- how to solve any compatibility issues and increase awareness about it
- which methodology is best to describe transition to free software to be basis of chosen strategy

General importance and relevance

In Estonia there are five state procurements about free software: one for software framework 2.0[5] and four for LibreOffice[6] (creating LibreOffice Estonia portal, translating, speller and thesaurus, creating teaching material). Also the OECD report „Towards a more unified governance“ a brief summary of the recommendations tells, that there is a need to offer public services more effectively by unifying used standards, which increases availability (Office of the State, 2011). OECD suggests for Estonia to harmonize our IT-systems and increase co-operation between different ministries. These state procurements and OECD report also means open standards and file formats usage for hassle free exchange of electronic documents, which are available to all citizens regardless of wealth. According to the report of Opportunities for Cooperation between Estonia and Finland (Opportunities for Cooperation between Estonia and Finland, 2008) there is overall IT-market size

[5]http://www.riso.ee/et/node/518 06.07.2012
[6]http://www.riso.ee/et/LibreOffice-tugihanked 06.07.2012

40% of European IT market – this is reasonable amount of computers, which all needs software. Reducing government and its subordinate establishment administration expenses is also one of OECD recommendations – especially, when it has 40% of EU IT-market. Such sustainable capability will be available when to use free software. When taxpayer's money remains to state there can be create new job places in Estonia and certainly in rest of Europe. Using free software there is no need to worry about licence fees and you can use it to as many computers as you need.

Estonia has also the document called State IT Architecture v1.01 (2007)[7], which defines among other things also saved document file formats (OpenDocument and Portable Document Format) which should be used at public sector and why not also other sectors. But mostly this document is not observed by citizens and also state staff and almost everyone is using those formats, what she/he wants to (mostly Microsoft Office ones). In such situation talking about interoperability at exchanging electronic documents between institutions is quite complicated. Here comes in free software and open, standardized document file formats with deployment strategies invented by this thesis. With proprietary file formats there is also vendor lock-in problem (Zhu, Zhou, 2007).

Preliminary ideas

A presentation of any preliminary ideas, the proposed approach and achieved results

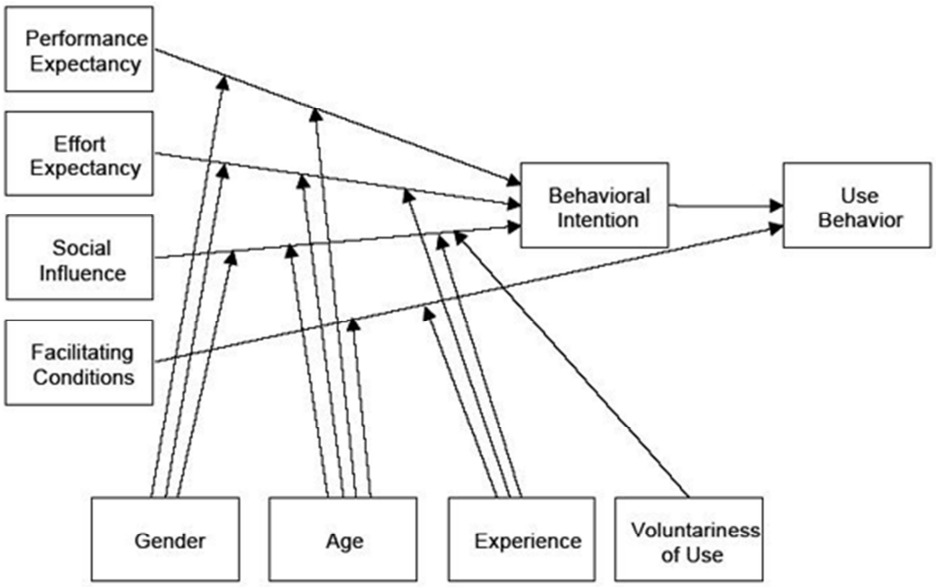
- *Current status of the research plan*

There are been reviewed number of articles of different free software assessment methodologies – TAM, TAM2, TAM3, UTAUT, UTAUT2 etc.
Articles are written:
Restructuring software systems in education and government, WCCE 2013 – this paper analyzed the need of mentioned topic by researching awarenesses and attitudes at public sector
Why is free software important in education, JTELSS 2013, FSCONS 2013 – this was a workshop in summer school to discuss keypoints of free software in education and in economy afterwards. Same workshop has been organized at small conference.
File formats security – proprietary vs open-source, HCI 2014 – this paper analyzed public sector web pages and available documents and its formats and possible sensitive data leak due fileformats.
Also several case-studies has been investigated but no good strategy has not been found yet from them.
Writing 3 articles currently – two as co-author (*Assessing free software transition risks by bowtie method and SWOT analysis; Vocational ICT curricula analysis and their correspondence to standards and qualification models*) and one as main author (*Free software user interfaces usability and aesthetics* – together with HCI Lab). One is planned (abstract were rejected from one

[7] http://www.riso.ee/et/koosvoime/RITA1_01.pdf 06.07.2012

magazine) in topic of „Free software transition model in case of different types of educational institutions“ (based on UTAUT and UTAUT2 model mostly).

- A sketch of the applied research methodology (data collection and analyzing methods)[8]



The UTAUT model - Unified Theory of Acceptance and Use of Technology by Viswanath Venkatesh, PhD

- *Expected achievements and possible evaluation metrics to establish the level of success of your results*

Analyze and find best choice by winterschool participants different methodologies and approaches of possible free software strategies.

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Expectations and motivation to attend Doctoral School

Discuss over methodologies of free software assessment methods and possible strategies and boost my research to right direction. Establish international contacts between researchers and possible cooperation (writing papers together).

[8] http://www.vvenkatesh.com/organizations/Theoretical_Models.asp

Physical Computing in Computer Science Education

Przybylla Mareen

2nd year
University of Potsdam
August-Bebel-Str. 89
14482 Potsdam, Germany
przybyll@uni-potsdam.de

Research area

Physical computing in computer science education is a rather new phenomenon. It has been applied in many other different disciplines for more than a decade now, as is reflected e.g. in the very popular maker movement [1]. Makers are very deeply engaged in do-it-yourself projects that often include computing skills besides crafting and using electronics and is driven by figuring out how things work to create, reuse or repair all sorts of devices. This includes two basic activities: exploring existing systems and expressing ideas in creating new systems. This way, constructionist learning takes place: guided by their own interest and for a personally relevant purpose, tinkerers actively construct knowledge [2]. Those activities, where interactive objects are made, can be referred to as 'physical computing'. The frequent development of new settings and also tools for physical computing demands a deeper investigation of the discipline in the context of computer science education. Physical computing allows students to develop concrete, tangible products of the real world, which arise from their own imagination. This can be used to provide them with interesting and motivating access to the different topic areas of the subject in constructionist and creative learning environments. In physical computing activities, learners bring together hard- and software components in creatively designing and creating interactive objects and installations with arts and crafts materials. In contrast to other hardware-centred approaches such as robotics activities, physical computing changes direction: it encourages learners to become creative inventors – something that enthuses teachers and students alike [3, 4]. Still, students can learn deeply with and about embedded and interactive systems – computing devices they come across on a daily basis in their everyday lives. Those people who implemented physical computing activities into their classrooms port great outcomes. What is unknown at the moment is a) why this is so, b) if students actually learn as good or even better than in traditional approaches (transfer of knowledge, long-term knowledge), c) if these subjective teacher experiences are measurable and d) if these experiences are scalable. It will therefore be investigated what effects physical computing has on students' motivation, on creative and constructionist learning, learning success and learners understanding of computing systems. It will be examined what opportunities are offered by physical computing and how these can be used most efficiently. Central questions to are: what do successful physical computing projects have in common, where do they differ from less successful ones and

what do teachers do in order to make physical computing work better for them? If this is known, it will be possible to design a blueprint for successful physical computing projects.

A working definition

In the first stage of research, it was important to come up with a working definition of physical computing in the context of computer science education. From a teacher's perspective, when designing a lesson plan based on physical computing, three things need to be taken care of: (1) What are the (conceptual) characteristics of the resulting products I want my students to create? (2) How is the creative process to be organized? and (3) How can I choose the right tools for my purpose?. Those aspects are interwoven and influence each other. Typical products of physical computing are interactive objects made with arts and crafts materials that are not transformational, but run continuously and interact steadily with their environment – be it other interactive objects, humans or the world in general.

Difficulty	Type	Features		Examples
easy	programmable toys			Finch, Beebot, Big Track
	programmable bricks (modular)			LEGO WeDo, LEGO Mindstorms, Pico Cricket
	I/O devices	everything on board with modules		Phidges, Theremino, Senseboard Kit
		everything on board without modules	sensing	PicoBoard, HCIs (e.g. MakeyMakey)
			acting	-
			sensing and acting	SenseBoard
		nothing on board		Vellemann Board
	micro controller boards	with modules		MyIG, Tinkerkit, Hummingbird, Gadgeteer
		without modules		Arduino-Family, Wiring Board, E-Textiles
	mini computers	with modules		Arduino TRE / Intel Galileo + Arduino-compatible modules, Raspberry Pi + PiFace
complex		without modules		Raspberry Pi, Beagle Board, Intel Galileo

Figure 4: Classification of suitable tools for physical computing

The processes in physical computing projects are usually creative arts and design activities that iteratively bring forth working prototypes and focus on ideas, not limitations. Concerning tools, there is a large variety of hardware available on the market already and more and more construction kits come with time. In order to decide for the right tools for a particular purpose, a classification of all these tools was necessary (Fig. 1). In a next step, the idea was to find out what students can learn with physical computing.

Contents, Contexts and Competences

In order to define the topic areas in which computer science and physical computing overlap, and thus to find relevant contents for physical computing in computer science courses in general education schools that go beyond introductory programming, different approaches were discussed and existing curricula analysed [5–8]. The review of earlier research ([9]), university programs (e.g. [10], [11], [12]), programs by other institutions (e.g. [13]) and textbooks (e.g. [14–16]) on the wider topic of physical computing has shown many different perspectives (e.g. Makers, Interaction Design, Embedded Systems) from which many contents and contexts relevant for computer science education were extracted that are not yet represented in computer science curricula (e.g. sensing

and acting, programming interactive objects, prototyping). In order to highlight key competences in the thematic area of physical computing, the afore-mentioned curricula served as guidelines [17, 18].

Design of the study

As it is very difficult to conduct empirical studies in regular classrooms where many variables can't be controlled, results of a single classroom can only be used for this specific situation to redesign the experience similar to what design-based research does. However, the number of teachers (and thus also students) who volunteer to participate in the study may even allow getting a sufficiently large data set to eliminate those effects. The current design of the study and its sub-studies is presented in table 1 and will be explained in more detail afterwards. Despite my very positive feeling that many teachers are willing to participate (because of the large number of teachers who signed up for a mailing list that was established for this purpose), we also set up a learning lab at our department. In this lab, teacher students are provided with everything they need to develop physical computing projects that will then be implemented with school classes from the region.

Table 1. Overview of the different sub-studies

Study	Student data	Instrument	Teacher data
Pre-study I: find the baselines	Questionnaire – Perceptions and conceptions of cs in everyday life and school contexts – Constructionist learning environments – Creativity promoting classrooms – Interests (general computer science projects) – Experiences, perceived competence in the field	Four-point Likert scale Value project proposals with grades Yes/No questions, free text	Informal expectations and experience reports from teacher-training workshops
Pre-study II: test run	Pre-test: – Reworked questionnaire from pre-study I – Interests (physical comp. projects) – Motivation Post-test I: – Questionnaire form pre-test – Learning outcome – Learning experience – Problems and strategies Post-test II: Long-term effects	See above KIM-test Quiz Video-taped presentations Free text Voice-recorded interviews Memory protocols (observations) Quiz	Conversation: – Informal expectations report from participating teacher Observations: – Lesson structure – Teaching methods and strategies Interview: Experiences – Problems and solutions – Perceived outcome – Ideas for future projects
Main study	Pre-test Post-test I Post-test II	Shortened pre-test II Based on pre-study II	Pre-intervention questionnaire: – Formal expectations report from participating teacher (free-text) Post-intervention questionnaire: – Formal experience report – Problems and solutions – Perceived outcome – Ideas for future projects

Learning Lab	Pre-test Post-test I	Shortened pre-test II Based on pre-study II	Pre-intervention questionnaire: – Formal expectations report from participating teacher (free-text)

Effects on different aspects of learning (student data)

One aspect that is to be investigated is the influence of physical computing activities on students' perceptions and conceptions of informatics in everyday life and education. In a recent survey among 115 pupils without any physical computing experience their perceptions of computer science lessons in terms of constructionist learning and creativity were examined to serve as a baseline for comparison later. The participants in this study were also asked about their associations with computer science in every-day life. It was found that embedded, physical and interactive computing systems are not in students' focus. None of the students asked had encountered physical computing activities in computer science lessons and only few learnt in creativity-rich lessons and constructionist learning environments. It became visible how interests in physical computing activities vary depending e.g. on gender [19]. The questionnaire from this study partly needed to be reworked for the pre-study to be conducted from October 2014 in a tenth grade elective course. Additionally, measurement methods needed to be chosen and developed in order to investigate the effects of physical computing concerning motivation and learning outcomes and are now evaluated. The main study will be designed based on the experiences from this preliminary study and conducted during the school year of 2015/16. The current learners questionnaire now captures statistical data, questions that investigate their perceptions of computer science classes on a ten item four-point-Likert scale, a standardized retrospective intrinsic motivation test (short scale of intrinsic motivation (KIM) [20]), questions that asks for students' expectations of computer science lessons, about their experience and perceived competences in the subject and about their interests in different physical computing project ideas. The answering time for the questionnaire is approximately 20 minutes. From the pre-study it was concluded that it should be shortened, as teachers might otherwise tend to interrupt students in order to start their lesson. A post-test will measure the delta to the pre-test, measure the learning outcome and additionally ask students to describe their learning experience. Both, quantitative and qualitative analyses are needed to evaluate the data. For the KIM test at the moment it is unclear if a certain value is high, low or average. Therefore, data from all the pre-tests will be evaluated and in the end serve as a standard to compare to. After the inventions it is also planned to interview selected students about their learning experience in order to find out more about which aspects of physical computing are influential in which direction. To evaluate the learning outcome and competences gained, final project presentations are video taped and will be analysed, e.g. with respect to the use of terminology (concrete vs. abstract), showing understanding of sensing and acting technologies, analogue and digital data, embedded systems design, etc.

Involvement of teachers

For both, physical computing projects with future teachers at the university level and teacher-training workshops with in-service teachers, questionnaires are used to reflect the participants' own learning experiences and to draw conclusions towards classroom use of the methods proposed. Another set of data will come from teachers who participate in a larger two-day workshop, in which physical computing activities will be developed. Those teachers are required to write a short text about their personal reasons for participating in the workshop. This way it is possible to get an idea about teachers' expectations. From all teachers who volunteer to cooperate and who implement physical computing into their lessons, experience reports and student data will be collected and evaluated.

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Expectations and motivation to attend Doctoral School

I attended the doctoral consortium in 2013 and was very happy to receive a lot of valuable feedback on my research ideas. I hope to have a similar experience this year. I'm in the middle of my pre-study in a local school and hope to get useful hints on how to evaluate my data and on how to improve my questionnaires and data collection methods in general before I start my main study next year. Another important issue for me at the moment is that I found several teachers who agreed to fill in a questionnaire for me and / or give me a short interview, where they report their experience of physical computing in computer science lessons. I would like to discuss, how I could structure this questionnaire to get the most out of it. My aim is to find out in detail what happened in the classroom, how they planned their lessons, how they instructed their students, what they gave them to make them start working (theme, challenge, task, …?) and which problems, surprises of signs of success occurred. Additionally, I thought about letting students write a test in the end of each intervention that will be compared against the average student who is taught without physical computing, e.g. on Bebras tasks for the particular age group, to see if effects for particular types of tasks can be detected. I'd like to discuss if this may be of any use.

Motivation in learning Programming

Nataša Mori

2nd year of study
University of Ljubljana, Faculty of Computer and Information Science
Tržaška 25
1000 Ljubljana, Slovenia
natasa.mori@fri.uni-lj.si

Research area description

The objective of research is to develop a methodology, which would increase student's motivation for programming and improve their learning outcome. This is highly dependent on the content and how it is presented. According to many authors (Graf, 2007; Dung, 2012; Garcia, 2007) adapting learning systems are better than traditional learning, but no experiment was made to support that. They all made an experiment that their automatic adaptation system is better than the system, which gets information about learning style by questionnaire. However, we suggest that motivation in relation to positive psychology (somehow traditional learning, same tasks for everyone) is better from adaptation systems.

- Graf, S., Viola, S. R. & Kinshuk (2007). Automatic student modelling for detecting learning style preferences in learning management systems. *Proceedings of the IADIS International Conference on Cognition.*
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A presentation of any preliminary ideas, the proposed approach and achieved results

In order to develop such a methodology, firstly we need to research what to teach, make a list of the concepts in programming that we want to teach and classify the tasks according to the mentioned concepts.

- **What to teach**

We focused on the first year in secondary school (students are 14/15 years old), because it is the only mandatory year of Informatics in our School System. Students (might) have no prior knowledge in Computer Science, that is why we start teaching them basic concepts of programming when they are already 14 or 15 years old. CS curricula exist for optional and mandatory courses of Computer

Science but they are very open. Therefore we compared CSTA K-12 Computer Science Standards, English Royal Society Report and Bavarian curricula with the current Slovenian curriculum and learning objectives to find out significant differences. The major difference has been found in the topics of algorithms and programming, which are mandatory (or optional) in United States, England and Bayern, but in Slovenia these topics are mostly optional and much more limited or there are none (Kristan, 2013, 2014).

- **Concepts in programming**

We focused on the basic concepts in programming (CAS, 2012, CS: A curriculum for schools, 2014, Computing in the national curriculum):

- Parameters
- Selection (if-then-else)
- Variables
- Repetition (iterative loops, while, for)
- Sequencing
- Language constructs that support abstraction (function and procedure)
- Recursion
- Interaction with the program's environment (input/output)

- **Classification of tasks in relation to concepts**

Above we classified the concepts, but we need to classify the tasks as well. This work is still in progress.

- **The role of positive psychology**

Positive psychology is a new branch of psychology, which focuses on well-being, happiness, joy, personal power, wisdom, creativity, imagination and the characteristics of positive groups and institutions. It is a young science that has begun with a speech by Martin E. P. Seligman. It is important to always be looking at how we can improve things (looking good qualities) and not, how do we correct the deficiencies.

- **Experiment in secondary school in 2013/2014 school year**

We were teaching Informatics in first year of gimnasium in the school year 2013/2014. We wanted to check students' motivation during learning programming. Therefore, we have prepared a short survey for students, which were answered before learning and after completion of learning. At the end of the school year, we had a discussion and come to some interesting conclusions.

We divided motivation for learning into three parts – initial motivation (before actual learning), intermediate motivation (during learning programming) and final motivation (at the end). The initial

and final motivation was very high, but we noticed the fall of motivation in the most important part – intermediate.

Although they had a lot of work and have learned many new things that were not easy, they were at the end of the school year happy and satisfied to have achieved all of this. Even those who did not like programming were glad with the result. However, it will be necessary in the future to add more elements of positive psychology, especially in the intermediate part, that students maintain motivation over a longer period.

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Expectations and motivation to attend Doctoral School

I want to discuss about my topic, methodology and goals with other senior researcher and students in this field, since I am the only PhD student at our faculty whose research is in the field of Computer Science Education. I would like to hear also other ideas and views, which would greatly helped me with continuation of my research.

Monitoring and assessing competence-based on-the-job training of IT professionals with semantic Web tools

Silver Püvi

1 Year of your doctoral studies
Tallinn University
Tulbi 6/6
Rapla, Raplamaa, 79514, Estonia
Silver.puvi@eesti.ee

Research area description

- Data exchange between different Education related Information Systems is often complicated and typical standards like MLO-AD, etc.. aren't used. Using standardized import/export possibilities makes IS working together. The adventage therefrom is learners movement between schools and from schools to workplaces. Described skills, knowledge and experience gives employeer possiblety to assess new workers and their earlier experience from school or from other workplaces.
- The aim of my research is proposing a sound and validated theoretical model along with a prototype of a semantic Web application, which supports both formative and summative assessment of ICT competencies in the setting of on-the-job vocational education and enables secure integration of competency-based e-portfolio systems with educational information systems through data exchange layer like X-Road.
- There are standards available, but most of them aren't used for educational Information systems. Estonian Educational Information system Interoperability Framework is described on Figure 1 doesn’t describe data exchange layer of different information systems. Also countries like Singapore and Finland who are also using or starting to use X-Road like information exchange layer.

  IEEE Learning Technology Standard Committee has published:

  - 1484.1-2003 IEEE Standard for Learning Technology-Learning Technology Systems Architecture (LTSA)
  - 1484.11.1-2004 IEEE Standard for Learning Technology-Data Model for Content to Learning Management System Communication
  - 1484.11.2-2003 IEEE Standard for Learning Technology-ECMAScript Application Programming Interface for Content to Runtime Services Communication
  - 1484.11.3-2005 IEEE Standard for Learning Technology-Extensible Markup Language (XML) Schema Binding for Data Model for Content Object Communication
  - 1484.12.1-2002 IEEE Standard for Learning Object Metadata

- 1484.12.3-2005 IEEE Standard for Learning Technology-Extensible Markup Language (XML) Schema Definition Language Binding for Learning Object Metadata
- 1484.13.1-20012 IEEE Standard for Conceptual Model for Resource Aggregation for Learning, Education, and Training
- 1484.20.1-2007 IEEE Standard for Learning Technology - Data Model for Reusable Competency Definitions
- P1484.2.1/D8 IEEE PAPI Learner — Core Features
- Etc…

CEN WS-LT LTSO has published:

- CWA 16076:2010 ECTS Information Package/Course Catalogue MLO Application Profile
- CWA 15455:2005 European Model for Learner Competencies
- Etc…

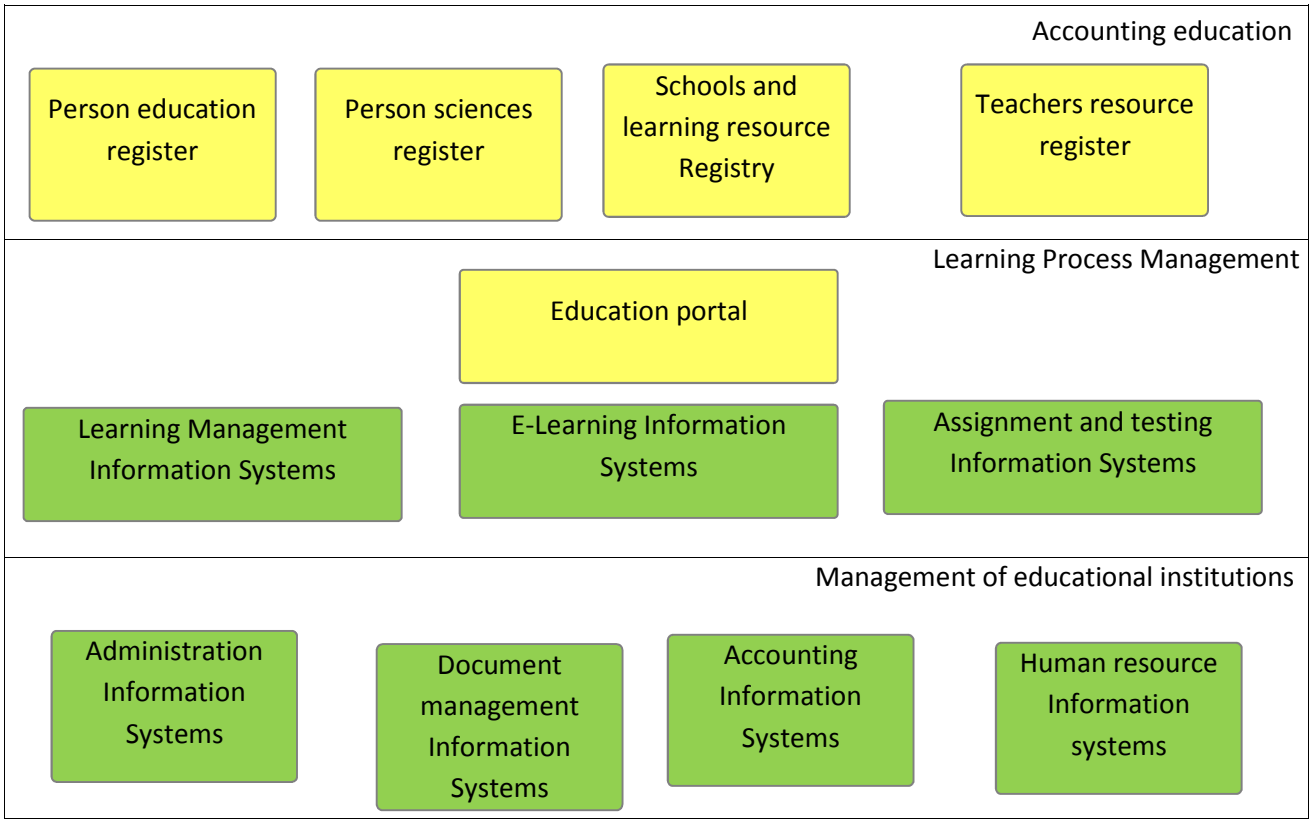

Figure 1. Estonian Educational Information System interoperability framework.

- Some ontology-based competency based tools or prototypes have been introduced, such as ‘‘CommOn’’ (Radevski, 2006), a framework for building competency based systems. CommOn is based on two models (implemented with specific tools) which guide firstly the building of competency reference systems related to particular domains such as healthcare or information and telecommunication, secondly the identification and the formal representation of competency profiles, and thirdly the matching of competency profiles. The CommOn framework allows one to build shareable ontologies and knowledge bases represented with semantic web languages and to

develop competency-based web services dedicated to human resource management. Also, other systems include ‘‘SMS – Skills Matching System’’ (Simona Colucci, 2003) which is a prototype that is not linked with e-learning systems, ‘‘GMS’’ (Jose Braga de Vasconcelos, 2003), which is an ontology-based competency management system for managing group competencies and which is not integrated with e-learning functionality or system (F. Draganidis, 2008).

In Europe, there have been three main projects that focus on ontology based competency development, but all of them have received lot of criticism and had little impact on vocational ICT education:

1. ‘‘TenCompetence’, which integrates models and tools in the creation, storage and exchange of knowledge resources, learning activities, competence development programmes and network data for lifelong competence development (Specht, 2006);
2. ‘‘Knowledge on Demand’’ (Sampson, 2002), which aimed to design, develop and test a learning environment as a dynamic and adaptable online environment which allows the individual learner to acquire knowledge according to his/her personal learning needs, without however taking into account the organizational aspect of competency development; and
3. ‘‘Learning in Process’’, which addresses both the organizational and personal aspects and enables user-context aware delivery of e-learning material.

Moreover, the use of ontologies in e-learning applications has been theoretically researched, for example with the architectural proposal of a prototype system for e-learning using ontologies.

Additionally, many learning management systems integrate competency management features, without ontological support. For a detailed analysis of the main competency management features included in some popular LMS. For my research I would use developmental research cross sectional studies with design-based research. The range of research areas that relates to DBR includes cognitive psychology, observational research methods, human–computer interaction, software development, curriculum development and teaching practices. DBR is often used by educational technology researchers to address a range of research goals, it involves combining both qualitative and quantitative research methods and data collection/analysis techniques. My research will take 3 iterations

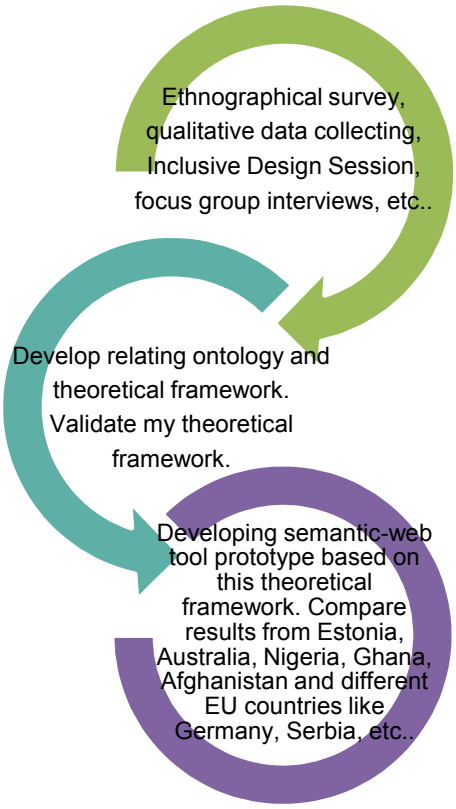

Figure 2. Research iteration

A presentation of any preliminary ideas, the proposed approach and achieved results

- Correntlly I am looking trought literature, standards and visit lessons what are related to my subject. Also I am analyzing terms of vocational ICT curricula and making domain ontology what is compliance with e-CF. From it I will produce an jurnal article about “Vocational ICT education curricula compliance to Educational Technology standards and competency model”
- Figure 2
- Expected achievements and possible evaluation metrics to establish the level of success of your results

  For measuring my model is important to pilot created sematic web with compatible IS. One project form HITSA (Information Technology Foundation for Eduaction) is developing a new Learning Management Information System where I can introduce my ideas.

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Expectations and motivation to attend Doctoral School

I would discuss my methodology and look forward for cooperation possibilities

Web evolutionary algorithm research and development of e. learning perspective

Airina Savickaite

First year of doctoral studies
Matematikos ir informatikos institutas
Akademijos g. 4
Vilnius, LT-08663, Lithuania

World Wide Web is one of the most important contemporary public environments for the information publication. Web developments suggest that Word Wide Web is not only for hosting information or search system. In the future, about the year 2018, is planned start of intelligent web.At the time, are expected to each participant in the World Wide Web get not only the real-time information, but also offer solutions. Is expected that each person will have their ownvirtual assistant. The question is why same web of intellectual possibility can not be adapted to the training environment, and how it could help the learner to master the knowledge and practical skills.So the subject is relevant to contemporary society of learners, scientific and practical sense. The object of research is computer engineering and educational structures. The aim of the improved web -create algorithm and adapt it to a computer learning environment in order to improve educational outcomes. Tasks. Web evolutionary algorithm to explore the application of e. learning systems and optimization aspects. An improved web evolutionary algorithm model. Create a proposed algorithm implementing a prototype system. To validate the proposed method proposed by implementing a prototype system. Expected outcome - Developed prototype, which with improved web algorithm to achieve better learning outcomes.

Research area description

- Not all web development solutions are applied to e.learning environment computer training
- Set the web development failures important for computer learning
- Not all web opportunities principles used e.learning environment
- Was a pilot test which has been discovered that the standards are not applied on the e-learning environment, people do not have good access to information.

A presentation of any preliminary ideas, the proposed approach and achieved results

- The fourth generation web standard preliminary algorithm -personal assistant
- The fourth generation could be good solution in e.learning enviroment -feedback for students.

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Expectations and motivation to attend Doctoral School

To find a solution – create algorithm for web development useful

A Multivariate analysis of the educational outcomes

Dovilė Stumbrienė

First year of doctoral studies
VU MII
Akademijos st. 4
Vilnius, LT-08663 Lithuania
dovile.stumbriene@mii.vu.lt

The main problem

PISA (Programme for International Student Assessment) results show that socio-economic difference is the strongest single factor associated with performance in PISA, accounting for about 50% of all variation in student scores. On average, about 30% of all variation lies between schools. More over the level of students' engagement at school, motivation, learning strategies are related to educational outcomes – those who are habitual readers and who enjoy reading are more likely than others to have high levels of reading literacy.

The aim of research

The input-output research on schooling effectiveness. The aim of research is to identify and measure the in-school and out-of-school factors that contribute to educational outcomes. For example, five categories of inputs can be included: student characteristics, family characteristics, peer group (classmates) characteristics, teacher characteristics, and school characteristics.

A sketch of the applied research methodology (data and methods)

The analysis consists of a multivariate econometric model used to explain variations in performance scores. The explanatory variables are student, family, peer group, teacher and school characteristics.

The data sets used are PISA. PISA is an international large-scale study that focuses on the capabilities of 15-year-olds in reading, mathematics, and science literacy. Starting from PISA 2000, it is conducted every 3 years, with a primary focus on one area for each cycle. The data included about 4600 students from 216 schools in Lithuania. There are two main questionnaires (Students Questionnaire and School Questionnaire) and three additional questionnaires (Educational career Questionnaire, Parent Questionnaire, ICT familiarity Questionnaire).

The multivariate analysis uses a three-level hierarchical linear model with mathematics achievement as the dependent variables. Independent variables of the first level are student and family characteristics, the second level – peer group characteristics and the third level – teacher and school characteristics. The benefit of multivariate modelling is the decomposition of the variance components between levels.

Discussion

1. There are more international and national educational outcomes databases: PISA, TIMSS, PIRLS and national educational data sets. Would it be useful to analyze more educational databases, but the problem is how to link these databases? There are different performance year, age of the participants, subject and so on.
2. To do educational outcome monitoring would be good to create the educational monitoring index.

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Computational modelling of informatics concepts through interactive tasks

Gabrielė Stupurienė

1st year PhD student
Vilnius University Institute of Mathematics and Informatics
Akademijos str. 4,
Vilnius, Lithuania
gabriele.stupuriene@mii.vu.lt

Research area description

- Concepts of informatics play a central role in all curricula and standards for informatics education at secondary schools. In practice at schools however very often the training of skills in application software is given much more room than the understanding of fundamental concepts of informatics. The international Bebras contest on informatics and computer fluency has the goal to convey informatics concepts to as many school students as possible in a way that can motivate them to be more interested in informatics (*Dagiene, V., Futschek, G. (2010) Introducing Informatics Concepts through a Contest. // IFIP working conference: New developments in ICT and education. Amiens: Universite de Picardie Jules Verne. ISBN 9782953728514*). Interactive tasks are more attractive and very necessary type of tasks. There are problems with tasks representation in different operating systems, lack of export tools.
- The **aim of research** – to create recommendation lists of the key informatics concepts according to pupils' age groups, to prepare methodology of interactive tasks development and a computer model.
- **The preliminary plan is**:
  - To inspect peculiarity of the contemporary informatics concepts and to identify the problems related with.
  - To create classifications and ontology of informatics concepts.
  - To prepare methodology of interactive tasks development.
  - To perform expert assessment of computer model.

A presentation of any preliminary ideas, the proposed approach and achieved results

- I am in the beginning of my research, so at the moment I am trying to perform a systematic literature review. I am looking for the key informatics (computer science) concepts.

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Assessment in computer science education

Willem van der Vegt

Just starting my doctoral research
Windesheim University for Applied Sciences
PO Box 10090
8000 GB Zwolle The Netherlands
w.van.der.vegt@windesheim.nl

Research area description

- In the Netherlands computer science is a non mandatory subject in secondary education. There is no national examn, like for other subjects as mathematics and geography; schools have to organize there own assessments, based on the goals of the national curriculum. There are a lot of pactical tests and there seems to be a lack in the area of testing of knowledge and understanding of concepts of computer science.
  How is the assessment practice? Are the goals of the curriculum reached in education? Are the tests, developed and used by teachers, valid tools to assess computer science education? Can other means of testing, like parts of the Bebras Contest, be used for assessing the intended conceptual thinking? And what skills do teachers need te develop to use proper testing tools in their school practice?
- The research aimes to collect valid examples of testing, to formulate improvements for assessing computer sciene in the secondary education, and to describe the needed Pedagogical Content Knowledge for teachers in computer sciences education.
- Crombach and Quirck (1976), Messick (1989) and Hubley and Zumbo (2011) developed means to investigate the validity of a test.

  De Gruijter (2008) treated the techniques for test contruction.

  Schmidt (2007) collected aids for computer science teachres to develop their assessments.

  Zwaneveld, Perrenet en van Diepen (2009) discuss the situation of the topic computer science and computer science teachers in secondary education in the Netherlands.

  Peeters (2014) offers a platform for computer science teachers, where they can share examples of the tests they have developed.

  McNamara (2005) investigated the relation between different kind of test questions in computer science.

The Bebras Contest (Bebras, 2014), in the Netherlands „de beverwedstrijd“ (2014) is a challenge for pupils from primary and secondary education on computer science and ICT. Tasks are shared in an

international task pool, so it is easy to compare the results on questions of pupils form different countries.

Dagiène & Futchek (2008) investigated criteria for good tasks.

Van der Vegt (2013) described the problems in predicting the difficulty level of the Babras tasks.

Shulman (1986) uses the term Pedagogical Content Knowledge to describe the disctinction between a teacher and an expert.

Henze, van Driel en Verloop (2008) investigated the Pedagical Content Knowledge for science teachers.

Saeli (2012) described how textbooks and teachers use Pegagogical Content Knowledge with the subject of learning about programming.

Koppelman (2008) applies Pedagogical Content Knowledge in the domain of UML class diagrams.

- We will (try to) show how to measure the validity of tests in computer science education, we will distinguish several test types to use in computer science educatio and we will desribe the Pedagogical Content Knowledge that an expierienced computer science teacher needs to be able to perform proper assessments in computer science education.

A presentation of any preliminary ideas, the proposed approach and achieved results

- This plan is only the first draft. The ideas are green and sometimes even undiscussed yet...
- We intend to collect already used tests for computer science and to match these tests to the goals of the national curriculum (Eindexamenprogramma). In interviews with teachers we will match the content of the tests with the goals of the curriculum and we will look for tools to analyze the validity of these tests.

  We will make an international comparison of the results of some questions of the Bebras contests and investigate if these questions match with parts of the curriculum in several countries.

  And there will be more to come...

- We will for instance compare different question types for the same topic.

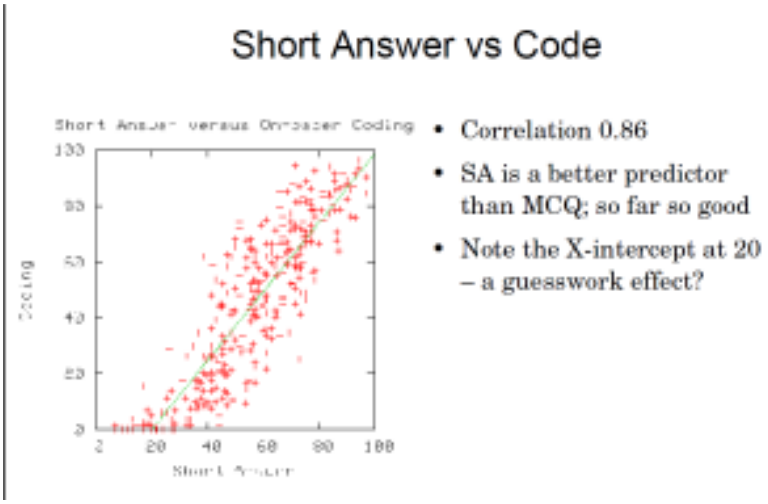

Figure 1. Relation between scores on different question types (McNamara, 2005)

And we will look for differences between the country results in the Bebras contest and try to find a reason for it.

Table 1. Comparison of Bebras task results for different countries(fictional)

Task	LT	NL
2013-DE-01	65%	52%
2013-SI-09	47%	39%
2013-BE-13	55%	70%.

It looks like the task 2013-BE-13 suits the Dutch pupils better. Is there a relation to find between these results and the goals of the national curriculum? Can we find other tasks that show the same difference?

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Expectations and motivation to attend Doctoral School

Since I am fresh and new in this field, I am not sure what I to expect. I hope to be able to share my thougts, ideas and experiences with a lot of open minds, critical colleagues, and to receive suggestions to improve my thinking, to add to my to-do- and to-read and to-study-lists.

The other side of this medal is that I have my experience to offer. I have worked for over 30 years as a techers trainer, I have assisted around 40 schools in starting with courses in computer science, and I am involved in the Olympiad in Informatics and in the Bebras Contest. I look forward to meet the people from this international community, and also to meet with new and other people, that are interested in research on computer science education.

After this doctoral school I will have a few weeks left to write my formal proposal in order to apply for a grant that will enable my to create time to do my research. I intend to listen carefull to all suggestions and I hope to improve my first draft to a healthy and solid research proposal.