Final Activity Report

1. Project Information

Project title (Romanian and English)

Predarea, învățarea și evaluarea într-o lume distanțată social

TEaching, Learning and EValuating in a sociAlly disTancing wORld

Acronym: ELEVATOR

https://www.cs.ubbcluj.ro/~avescan/elevator/

Romanian Partner: Babeș-Bolyai University
Foreign partner: University of Namur
Duration of the bilateral project: 2 years

2. Project Objectives

The project has two complementary objectives related to learning: first, considering innovative solutions and approaches to design effective learning activities, and second, concerning the development of tools to diagnose and remedy students' misconceptions.

In year 1
- Analysis of practical problems by researchers and teachers in collaboration
- Building of an open-ended questions survey (including pre-post-tests) to collect data from students participating in a testing course (January-February 2021)
- Data collection for the testing course (February-2021)
- Data analysis for testing course (May-December 2021)
- Building of concept inventories for three courses (Augustus-October 2021)
- Data collection with concept inventories (October-December 2021)

In year 2
- Data analysis for testing course (data of year 1) (January-June 2022)
- Building of concept inventories for testing course (January-February 2022)
- Data collection (February-May 2021)
- Data analysis for testing course (data of year 2) (May-July 2022)
- Data analysis for the three courses (January-June 2022)
- Improvement of the concept inventories (July-October 2022)
- Improvement of teaching materials, recommendations, innovations, reflection on the production of design principles for teaching materials according to identified misconceptions (**iterative process**)
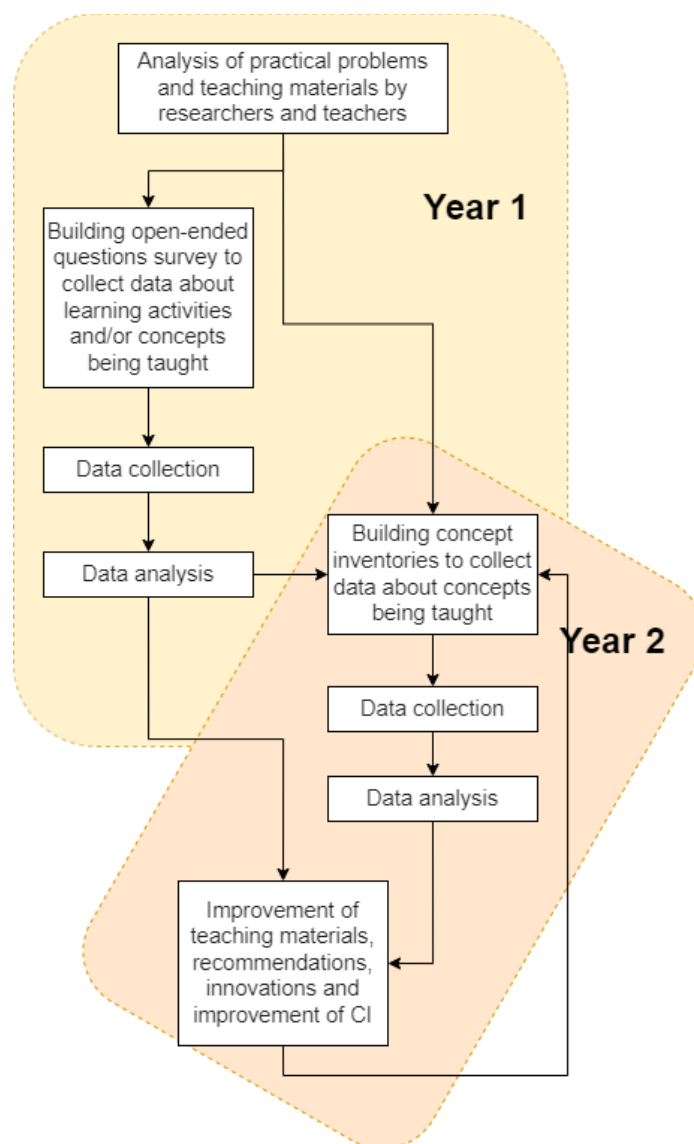
Figure 1. Activities of the ELEVATOR grant

The results of the project are provided below.

Outcomes
- **Four concept inventories** to measure students' lack of understanding of key concepts in four different courses - reusable from year to year to identify improvement points in these courses, but also as **self-assessment tools** for students
- A list of **misconceptions validated by the data collected** for each of the four courses evaluated.
- **Recommendations for evaluated teaching materials, solutions suggestions,** pedagogical innovations
- **Design principles for teaching materials** according to identified misconceptions

3. Research Visits

To carry out this project and ensure the best possible collaboration, regular online meetings were held from the very beginning of the project, helped by the infrastructure deployed by the two universities in the context of the current sanitary situation. These meetings were first used to define how the planned activities would be carried out. Then, regularly held meetings helped make sure that the activities envisaged during the writing of the project are finally adapted to the real contexts imposed by the sanitary situation. The two teams had to align their way of working and train each other in the qualitative approaches and vocabulary of the software engineering field, respectively.

During the year 2021, two research visits were conducted.
- During the week of 30th August 2021, the Romanian team (Alexandra Pasca, Camelia Serban, Andreea Vescan) visited the Faculty of Computer science of the University of Namur.
- During the weeks of 22nd and 29th November 2021 (4th December 2021), the Belgian team (Julie Henry, Bruno Dumas) visited the computer science department of the Babeș-Bolyai University.

During the year 2022, two research visits were carried out.
- During the week of 25th April 2022, the Romanian team (Alexandra Pasca, Camelia Serban, Andreea Vescan) visited the faculty of Computer Science of the University of Namur.
- From the 21th November to the 3rd December 2022, the Belgian team (Julie Henry - 2 weeks, Fanny Boraita Amador - from 21th to 24th November) visited the Computer Science department of the Babeș-Bolyai University.

The research visits had the objective of improving the collaboration activities of the two teams.

The occasion was used to present the research activities of the two teams in front of an audience composed of local computer science researchers. In Namur, the Romanian team presented their activities in digital education as well as software testing, and in Cluj-Napoca, the Belgian team presented their activities in digital education as well as in human-computer interaction. The goal of those two seminars was to help disseminate the project initial results, the respective expertises of the two teams, and help foster potential new collaborations.

Furthermore, the time of the 2021 visit was used to coordinate data analysis activities, as these require a high level of agreement between the analysts to provide relevant results. It was also the occasion to set up, define and write a major part of a paper that was submitted to ACM TOCE journal (Transactions on Computing Education). The TOCE paper will be updated with the pre-post analysis of the SSVV study and with the validation of the misconceptions with the cohort of students from 2021/2022.

The research visit to Namur (Belgium) in 2022 was used by the Romanian team to present the research activities and results of the ELEVATOR project: grant objectives,

methodologies, implementation, analysis, and results of the studies conducted in 2021 and 2022. The meeting was made up of local researchers in Computer Science. In Cluj-Napoca, the Belgium team presented different methods for evaluating and improving learning experiences in Computer Science, in particular the method implemented within the ELEVATOR project, but also methods implemented in other contexts that could inspire the project team. The aim of these two seminars was to help disseminate the project results, the respective expertise of the two teams, and to help foster potential new collaborations.

Furthermore, the time of visits was used to coordinate data analysis activities, as these require coordination among grant researchers to provide relevant results. This was also an opportunity to set up, define, and begin writing a paper that was submitted to the EASEAI workshop (within the FSE/ESEC conference).

4. Project Results

Several research activities were conducted: analysis of practical problems and teaching materials by researchers and practitioners (teachers), development of tools for qualitative data collection about learning activities and/or concepts being taught (concept inventories) and data collection from practitioners and students (in four different classes).

Course SSVV (Software Systems Verification and Validation) - Data was collected from students in a testing course through a set of open-ended questionnaires. This set, entitled "pimp my course", consisted of a pre-post-test (assessment of learning activities) and five questionnaires assessing concepts taught: BBT, WBT, levels of testing and exploratory testing, web testing and bug advocacy, and correctness. Therefore, seven collection times were organized over a 12-week period with a collection duration of one week for each questionnaire. Each questionnaire contains between 6 and 12 questions and counts between 60 and 80 responses.

The first-year study (2021) revealed that there are some misconceptions of the students regarding testing in general, particularly about white-box testing and black-box testing.

Data analysis revealed eight **misconceptions about testing techniques**, both black-box testing (BBT) and white-box testing (WBT) concepts, and testing in general. The themes are as follows.

1. *In BBT there is no access to design/architecture*
2. *BBT can be done only for unit-level testing.*
3. *WBT is done only for statements coverage*
4. *WBT does not test the functionality of the application.*
5. *Developers do not test*
6. *Testing is a guess process.*
7. *The code is immune to the same set of tests.*
8. *Testers do not need programming experience.*

Therefore, there are specific misconceptions about BBT (1,2) and WBT (3,4). Students also have misconceptions regarding software testing (in general 5,7). There are also misconceptions about the skills needed to test (6,8).

Analysis of data concerning the pedagogical design of the course, data collected in Academic Year 2021-2022. The purpose of this study (via pre- and post-test) was to evaluate the learning experience (including online learning due to covid) of the SSVV course and to suggest design directions. The questionnaires (pre and post) included questions about the design of the course. The results (processed by the external team, i.e. the Belgian team) still need to be confronted in more depth with the experience of the teacher in charge (Romanian team). However, some first findings can be described. For example, the distinction that students make between seminars and laboratories questions the added value of this pair of teaching approaches. In-class assignments are experienced as stressful and pressured, a result that can be related to the fact that students arrive at seminars without having attended the readings and without having seen/reviewed the material. Therefore, students logically prefer a combined individual work/take-home assignment/online learning approach. In addition, seminars that should emphasize extensive interaction between the teacher and the class, mixing questioning and application, are described by students as a place where the teacher should transmit concepts. As the lectures are little attended by the students, they try to find the content of the lectures in the seminars, which is not foreseen by the teacher.

Course APM (Advanced Programming Methods) - Lect.dr. Camelia Serban, undergraduates students in the second year of their studies. The study aims to identify misconceptions about the Delegate Design pattern.

The concept of delegation is studied in the APM course both in the Java language and in the C# language. Initially, it is studied in the Java language. The results of the pre-test questionnaire fix the students' pre-misconceptions of the delegation concept. The second questionnaire revealed that students changed their position on the text statements provided after the theoretical classes. Furthermore, the perception of the delegation concept by the students seems to stabilize after the C# courses. Thus, working on practical problems and learning-by-doing could have a positive impact on a better understanding of the abstract concept of delegation.

Course CMES (Computational Models for Embedded Systems) - Assoc. prof. Andreea Vescan - Master students, *Software engineering* and *Distributed Systems in Internet* sections. The study aims to identify misconceptions for the Finite State Machine concept.

The aim of the published paper [Hen2022] is to present an approach used to identify misconceptions related to the concept of a Finite State Machine (FSM). In the learning process, identifying misconceptions of students, that is, when they appear and how to efficiently correct them, are important aspects of the best learning result.

The results of the pre-test questionnaire (Q1) fix the students' pre-misconceptions of the FSM concept. The other questionnaires revealed changes in positioning in relation to text statements following theory courses (Q2-Q3), demonstrating their influence. Furthermore, the perception of the FSM concept by the students appeared to stabilize after the practical work was done (Q4). Thus, working on practical problems and learning by doing might have a

positive impact on understanding the abstract concept of FSM. However, the post-test questionnaire (Q5) shows that some doubts remain, confirming the students' learning difficulty.

Course MIPPIP (Mathematics for primary education) - Assoc. prof. Ioana Magdas - Master section *Preservice teachers for primary education,* The study aims to identify misconceptions for the Fraction concept.

The concept of fraction is one of the fundamental concepts of elementary mathematics, which is used in everyday life and on which the more advanced mathematical knowledge is based. The results of the initial test confirmed the students' misconceptions about fractions. After the first stage of the course and seminar application, some misconceptions changed. At the end of the experiment, the highest percentage of correct answers was close to 50%. If at the beginning of the experiment the average of correct answers to the proposed items was 14.6%, at the end of the experiment this percentage reached 34.2%, which shows that almost 20% of the students overcame their preconceptions and misconceptions about fractions. In addition, at the end of the experiment, an average of 20.1% of the respondents correctly argued the statements, although they chose a wrong answer. This fact shows that one in five students only partially understand the proposed statements and have general knowledge that is not sufficiently well structured, so they have difficulty choosing the correct answer. On the basis of the experience, it is therefore evident that more time needs to be allocated for the understanding and fixing of the fraction concept for future primary and pre-school teachers, a concept that is extremely important in the study of mathematics from primary education and later on in middle and high school, but also for life.

5. Project Results and Property Rights

As the results of the project consist mainly of theoretical results over computer science education, the best avenue for their dissemination resides in scientific publications. This dissemination step started with a submission to the journal ACM Transactions on Computing Education (TOCE) and with a publication to the EASEAI workshop (within the FSE/ESEC conference).

A website has been set up that contains the summary of the granted project, its objectives, and members of the team: https://www.cs.ubbcluj.ro/~avescan/elevator/. This website will be updated, especially with results and publications, after receiving notifications of submissions that will be made from results not yet processed.

6. Impact of results

The results of the project have an impact on a variety of aspects, from transfer of knowledge and generalization of learning design to students and the IT industry.

Collaboration and transfer of knowledge. Qualitative and quantitative analysis will be applied. The procedure of how to apply the qualitative analysis method will be transferred

from the Belgium team to the Romanian team, applying them also in classes from Babes-Bolyai University.

Learning Design Generalization. The innovative e-learning designs generated are supported by bilateral cooperation in this project. The generalization of these may be sustained by the fact that the study will be applied to classes and students from both universities. In addition, early misunderstanding diagnosis approaches will be used at different study levels: undergraduate and master.

Our findings can help teachers improve the explanations of courses that include testing concepts. Additionally, considering that the study only used students from the two universities, identified misconceptions should also be investigated with other cohorts in other universities. The generality of the discovered misconceptions can also be tested through the use of the Software Testing Concept Inventory (STCI) that we plan to develop based on our findings. Early administration of the STCI at multiple institutions could reveal that more cohorts of students possess software testing related misunderstanding.

Erasmus+ agreement (2021). The bilateral cooperation in this project has as collateral impact the sign of an Erasmus+ agreement between the two universities: Key Action 1: Learning Mobility for Higher Education Students and Staff.

Impact of results. The learning designs and diagnostic approaches obtained can improve both theoretical and practical parts of the software testing domain. The theoretical part refers to software testing courses that are taught in colleges/universities. In the IT industry, students will use concepts learned in the courses, so it will be better to make sure that students have understood the concepts before applying them wrong in industry.

Young researchers. The young researchers participating in the grant activities learned about conducting research and collaboration and improved not only technical and research skills but also soft skills.

7. Summary

Learning is a process of knowledge construction and in this process, teachers and students are partners. Students no longer want to play a passive role in their learning process, but prefer to have an active role. Also, teachers need to facilitate learning and think about assessment, i.e. how to correctly diagnose student's lack of understanding and how to design better learning experiences to highlight the concepts and their understanding (acquired skills).

Our project investigates and proposes solutions related to both effective learning design activities and approaches to early diagnosis of misunderstanding, especially in an online learning context.

In 2022, to ensure the best collaboration between the Belgian and Romanian teams, online meetings were also held. These meetings were used to define and plan the activities that have been carried out.

Several research activities were conducted: analysis of practical problems and teaching materials by researchers and practitioners (teachers), development of tools for qualitative data collection about learning activities and/or concepts being taught (concepts inventories), data collection from practitioners and students (in different classes), data analysis by research team and results (for all studies).

The research visits had the objective of improving the collaboration activities of the two teams. Teo research visits were carried out: during the week of 25th April 2022, the Romanian team visited the faculty of Computer Science of the University of Namur and during the week of 21th and 27th November 2022 (3rd December 2022), the Belgian team visited the Computer Science department of the Babeș-Bolyai University. The occasion was used to present research activities and results of the research work of the two teams in front of an audience composed of local researchers in computer science. In Namur, the Romanian team presented research work (the grant objectives, methodology, implementation, analysis, and results of studies conducted to discover early diagnostic approaches). In Cluj-Napoca, the Belgian team presented their experience and activities in evaluating and improving learning experiences in computer science. The goal of those two seminars was to help disseminate the project work, the respective expertise of the two teams, and to help foster potential new collaborations.

Furthermore, the time in presence was used to coordinate the data analysis activities for the collected data, as those require a high level of agreement between the analysts to provide relevant results.

Project managers,

PI Romania
Assoc. prof. dr. Vescan Andreea

PI Belgium
Prof. Dr. Dumas Bruno