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: a first one considering innovative solutions and approaches to design effective learning activities, and a second one 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 testing course (February-May 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, recommandations, innovations, reflection to produce design principles for teaching materials according to identified misconceptions (**iterative process**)

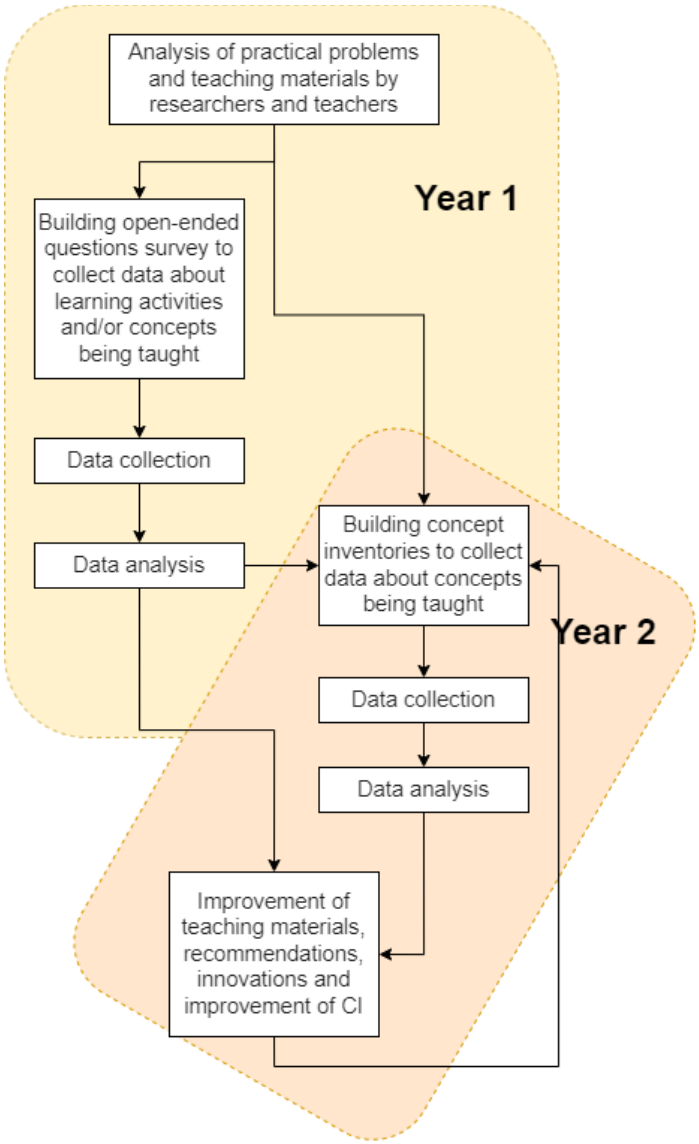

Figure 1. Activities of the ELEVATOR grant

The outcomes of the project are provided next.

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 teaching materials** evaluated, suggestions for solutions, 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 start of the project, helped by the infrastructure deployed by the two universities in the context of the current sanitary situation. These meetings were used first 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 carried out.

- 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.

Research visits had the goal to enhance the collaboration activities of the two teams.

The occasion was used to present research activities of the two teams in front of an audience composed of local researchers in computer science. In Namur, the Romanian team presented their activities in digital education as well as in 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.

Furthemore, the time in presence was used to coordinate the data analysis activities, as those necessitate 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 to be submitted to ACM TOCE journal (Transactions on Computing Education).

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 (concepts 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. So seven collection times were organized over a period of twelve weeks with a duration

collection of one week for each questionnaire. Each questionnaire contains between 6 and 12 questions and counts between 60 and 80 responses.

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

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.

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 data collected are numerous, allowing both qualitative and quantitative processing. Some of the data provide information on the pedagogical interest of the proposed learning activities, on the students' desires and on the difficulties they may encounter in a distance learning context. Other data help to identify misunderstandings among students about the concepts being taught. In general, the analysis of these data will lead to recommendations for improving the teaching materials, and reflection to produce design principles for teaching materials.

For the **SSVV course,** several misconceptions were identified, some are related to the Black-box testing and White-box testing approaches, two are general testing misconceptions and two are related to the skills required to test. Table 1 outlines them.

TM1	In BBT, there is no access to design/architecture.
TM2	BBT can be done only for unit-level testing.
TM3	WBT is done only for statements coverage.
TM4	WBT does not test the functionality of the application.
TM5	Developers do not test.
TM6	Testing is a guess process.
TM7	Code is immune to the same set of tests.
TM8	Testers do not need programming experience.

Table 1. Identified misconceptions based on the qualitative analysis: 8 Testing Misconceptions

The identified misconceptions need to be also 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 the software testing related misunderstanding.

The conducted study, along with the design methodology and the obtained results are currently being submitted to the journal ACM Transactions on Computing Education (TOCE). In the TOCE paper, only a few questions from two questionnaires were analyzed: the BBT questionnaire and the WBT questionnaire. Three questions on testing in general and one question on the concept of BBT were considered in the first questionnaire. In the second questionnaire, only the question on the concept of WBT was considered.

The studies elaborated for the **APM, CMES** and **MIPPIP** disciplines, i.e. misunderstandings of various concepts taught, will be performed in the second year of the project. Currently, the teachers and researchers are collecting data.

5. Project Results and Property Rights

As the results of the project mainly consist of theoretical results over computer science education, the best avenue for their dissemination resides in scientific publications. This dissemination step has also started with a submission to the journal ACM Transactions on Computing Education (TOCE).

The homepage of the grant that contains the summary, objective, team members: https://www.cs.ubbcluj.ro/~avescan/elevator/
The page will be updated with the publications and results after receiving the notification from the journal editor.

6. Results Impact

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

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

Our findings can help teachers to improve courses' explanations that include testing concepts. Also, considering that the study used students from the two universities only, the

identified misconceptions need to be also 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 the software testing related misunderstanding.

Erasmus+ agreement. 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. In this respect,

Results impact. The obtained learning designs and diagnostic approaches can improve both theoretical and practical parts of the software testing domain. Theoretical part refers to software testing courses that are taught in college/university. 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, 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.

Regular online meetings were held from the very start of the project to carry out this project and ensure the best possible collaboration. These meetings were used first 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.

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), and data collection from practitioners and students (in four different classes).

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Project managers,

PI Romania
Assoc. prof. dr. Vescan Andreea

PI Belgium
Prof. dr. Dumas Bruno