# Scientific and technical 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 General 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.

Given the health and distance learning context, it was decided to already cross the two objectives in the first year. 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). 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.

## 3. Execution Phase Project Objectives

The activities performed in order to achieve the objectives are listed next, the major steps being represented graphically in Figure 1.

**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**)

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

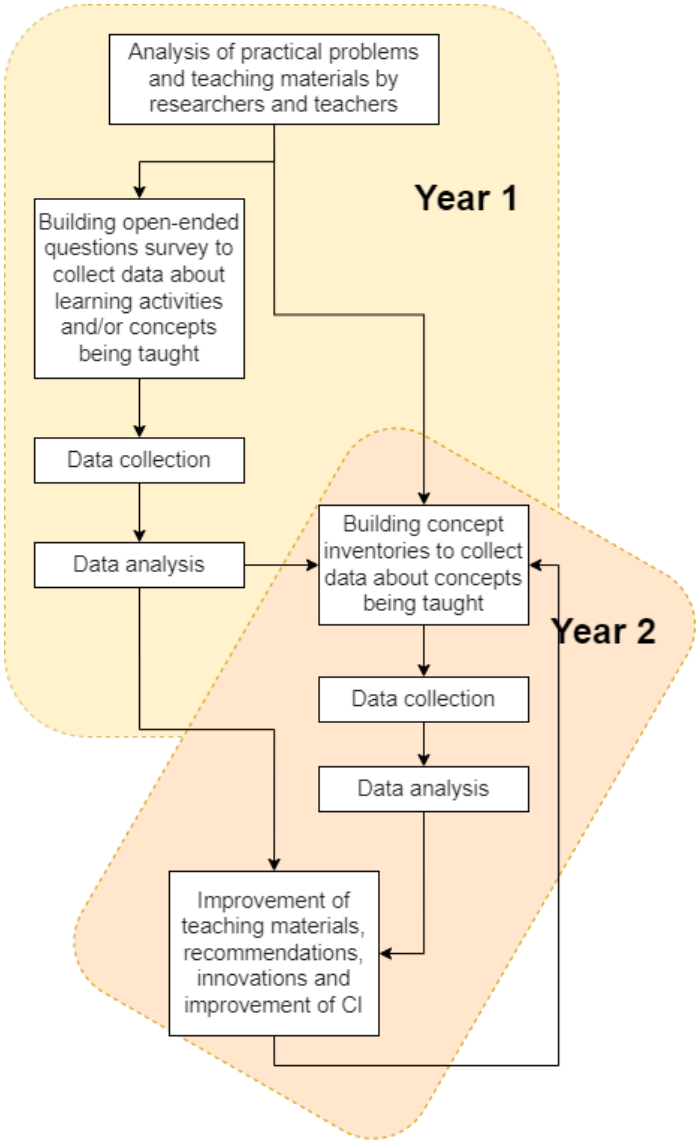


Figure 1. Activities of the ELEVATOR grant

## 4. Scientific and Technical Description

In the current context, it is important to identify the elements that make teaching and learning online successful (**challenge 1**). This involves understanding how to adapt the teaching/learning process, but also thinking about how to design activities that engage the students in active learning so that they stay in the flow (being attentive during class). This is particularly important in a formal domain such as computer science where practice is pervasive.

The learning activities nowadays are no longer pure transfer of knowledge from teacher to students but the students take part in building the knowledge: we, teacher and students, are

partners in learning. The design of the learning activities need to actively involve the students in the process of learning. It is not only a question of adapting teaching and its content, but also of thinking about evaluation. It is important that students, made more autonomous by the context, are able to assess themselves regularly, but also that teachers are able to propose assessment tools to correctly diagnose students' misunderstandings and highlight their understanding (acquired skills) (**challenge 2**).

To meet these two challenges, the project has two complementary objectives: 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.

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).

In year 1, 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.

The online questionnaires were accessible on the platform used at the Babes-Bolyai University (Microsoft 365). The students would then log in with their usual identifiers.

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.

Educational research often favors a mixed methodological approach, combining elements of both qualitative and quantitative research. Quantitative and qualitative methods are complementary. On the one hand, qualitative data provides rich, in-depth and diverse information compared to quantitative data. They are particularly useful when seeking to explain the how and why. On the other hand, statistics are incomplete if the information collected from real actors (students, teachers) that give meaning to all these figures is missing. The project is conducted as an **embedded design**, a mixed methods design where one type of data is most relevant to the researchers. In the case of this study, the qualitative data takes precedence over the quantitative data. The quantitative data provides a supportive, secondary role.

For the analysis, the data were completely anonymized and duplicates have been removed. Because it is qualitative data, the appropriate analysis is the coding. In the beginning of the study, all researchers from the Romanian team received coding training from the Belgian team. Then, the coding schemes took place in two phases: open coding and axial coding.For each question, preliminary data coding (**open coding**), using inductive codes generated by the qualitative data itself, is manually realized by two researchers (a Belgian and a Romanian). To reinforce the rigor of the coding schemes and protect against bias and premature conclusions, the data were coded individually. Each response of an open-ended question is considered as a unit to be coded. However, some long responses were split into several units to ensure consistent coding. The codes obtained during this first phase were discussed with all the researchers and only those on which they unanimously agreed were retained. Then, for each question, the selected codes are grouped into categories by two researchers (a Belgian and a Romanian), forming new codes (**axial coding**). Disagreements were solved through discussion between the two researchers involved in this second phase.

Analysis of coded data and identification of misconceptions were done, for the TOCE paper, by the Romanian team, due to their expertise in the field. Other members of the research team were asked to review the findings and provide feedback.

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

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. Code is immune to the same set of tests
8. Testers do not need programmer experience

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

## 5. Executive Summary of Activities

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).

Research visits had the goal to enhance the collaboration activities of the two teams. Two research visits were carried out: during the week of 30th August 2021, the Romanian team visited the Faculty of Computer science of the University of Namur, and during the weeks of 22nd and 29th November 2021 (4th December 2021), the Belgian team visited the computer science department of the Babeș-Bolyai University. 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.

## 6. Economic Capitalization of the Obtained Results

Our project studies efficient learning also in the e-learning context, from two perspectives: design learning activities for specific concepts and their understanding (acquired skills), thus providing early diagnostic approaches for misunderstandings of students.

**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.

**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 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.

Project managers,

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Prof. dr. Dumas Bruno