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IMPLEMENTING A RAPID APPLICATION DEVELOPMENT COURSE IN HIGHER EDUCATION AND MEASURING ITS IMPACT USING KIRKPATRICK'S MODEL: A CASE STUDY AT VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

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Abstract. Nowadays, technological development and improvement in business is happening rapidly, so higher education (HE), and not only, studies should constantly provide and develop new up-to-date knowledge and skills to students, in order to train competitive specialists, address digital transformation by developing digital readiness of higher institutions, and increase employment opportunities of students. Consequently, this paper discusses the implementation of the newly developed courses for teaching Rapid Application Development (RAD) on the Oracle Application Express platform into the studies at Vilnius Gediminas Technical University (VILNIUS TECH) and presents the effectiveness of the implementation of this course measured using Kirkpatrick's model. The obtained results show that students' knowledge of RAD increased after attending the course. In addition, a 76% agreed that this course increased their knowledge of the subject matter.

Keywords: rapid application development, low code, knowledge evaluation, Kirkpatrick's model, higher education, digital transformation.

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1. Introduction

Higher education (HE) plays an important role in preparing young people for the labour market. Many universities around the world offer different study programmes. Usually, each university tries to provide education and knowledge oriented to the latest trends and technologies. The main role of a university is to prepare the best specialists in the field who could easily find a job. Therefore, the employment rate of graduates is often used to evaluate the university and the quality of the education provided.

Not only employment but also employability should be taken into account when trying to improve higher education. Cheng et al. (2022) discussed the definition of employability and its relationship to HE. As employability is an important concept in HE, it should be considered from the perspective of both students and teachers. The study conducted by Brooks et al. (2020) outlines that students view HE in three different ways: 1) as preparation for the labour market, 2) for personal growth, and 3) for contributing to the progress of society. Teachers educate students and provide knowledge as best as they can. On the one hand, employability depends on a personal characteristic. On the other hand, HE can improve an individual's knowledge and help to grow as a specialist in the chosen field.

The study by Monteiro et al. (2022) presents various factors that influence employability. While some factors can't be changed, such as gender or age, others can be improved, such as work experience, education or competencies. Perez-Encinas and Berbegal-Mirabent (2022) also studied the factors affecting employability as a set of competencies, understanding and personal attributes. These authors, as well as Monteiro et al. (2022), pointed out that higher education institutions (HEIs) are responsible for producing highly qualified graduates.

Rapid technological progress is leading to the search for new ways of teaching students in HEI. Because of the responsibility to provide quality studies, five European universities joined forces to implement the project introducing a new approach to software development. Vilnius Gediminas Technical University (VILNIUS TECH) in Lithuania as the coordinator, Tallinn University of Technology (TalTech) in Estonia, Riga Technical University (RTU) in Latvia, Technological University Dublin (TU Dublin) in Ireland, and University of Rijeka (UNIRI) in Croatia formed a consortium and started to implement the Erasmus+ HE cooperation project KA220-HED-E99B8F14 "Embracing rapid application development (RAD) skills opportunity as a catalyst for employability and innovation" (RAD-Skills) in 2022.

The aim of the project is to provide RAD skills to students of these universities in a similar way and to prepare young talents for the job market. The project is being implemented in cooperation with the Oracle Corporation, which is providing free access to Oracle Cloud Infrastructure (OCI) for teachers and students, and supporting teacher activities through Oracle Academy.

This paper presents the implementation of the RAD skills course at VILNIUS TECH. The research in this paper focuses on two questions: 1) how the material introducing RAD approach has been added to the study programs; and 2) how the students have received and are satisfied by this course.

The rest of the paper is structured as follows. Related work is discussed in Section 2. Section 3 presents the course design and structure as well as the methodology used to evaluate the course. The results of the evaluation are given in Section 4.

2. Related works

Due to the constant improvement of information technologies, software development should be fast and furious. Traditional software development approaches are struggling to keep up with this fast pace of change. Therefore, new alternative approaches have emerged to meet the evolving software requirements. One such approach is Rapid Application Development (RAD). The RAD methodology allows for rapid prototyping and adaptability to changes in user needs (Singgalen, 2024).

Low-code development platforms (LCDPs), which allow software applications to be developed quickly and efficiently, are usually associated with the RAD approach (Robal et al., 2024). LCDPs provide visual interfaces that allow software to be created without manually writing source code. Among different low code environments, Oracle Application Express (APEX) can be used as one of the RAD tools (Baggia et al., 2019; Kvet, 2024).

As the popularity of Oracle APEX grows, Pastierik and Kvet (2023) evaluate its potential for software development. In their study, the authors describe the features of Oracle APEX

and determine its suitability for teaching web application development to students (Pastierik & Kvet, 2023).

However, the introduction of new software development tools into degree programmes poses another challenge. Teachers, especially in the field of computer science, should constantly improve their competencies and skills in order to prepare their students for the current labour market. This issue is discussed by Urem et al. (2020). The authors compare two learning methods (online training and in-class (i.e., face-to-face) training) and their outcomes. The paper by Urem et al. (2020) presents the Oracle Academy programme, which helps many teachers from educational institutions to improve their skills.

Regardless of the target group of the training (teachers of students), an evaluation of such training should be carried out. It is important to measure the achievement of learning outcomes, knowledge and skills gained after any kind of training. The paper by Dhankhar (2020) discusses the need for training evaluation and provides a comparative review of different training evaluation models. A similar review is carried out by Liu and Zu (2024) who explain different models of training evaluation and providing their advantages and disadvantages. Although there are different models to measure and evaluate the effectiveness of training, both studies conclude that Kirkpatrick's models are widely accepted and well-known training evaluation model (Dhankhar, 2020; Liu & Zu, 2024).

Alsalamah and Callinan (2022) conducted a bibliometric analysis of the Kirkpatrick's model to examine its effectiveness in evaluating training and educational programmes. The authors considered 416 articles in a study to prove that the Kirkpatrick's model is useful and applicable in various contexts. Although primarily this model is mainly used in the evaluation of medical education, other fields such as computer science, business or social sciences have also adapted this model (Alsalamah & Callinan, 2022).

Ghasemi et al. (2020) used the Kirkpatrick's model to evaluate the effectiveness of a scientific writing workshop for medical students. Assessment and evaluation are very important in educational programmes for several reasons. Firstly, it can show personal growth and knowledge improvement for individuals. Secondly, collecting the information from the participants can help to improve the programme itself and teaching methods (Ghasemi et al., 2020). As one of the widely used methods in assessment of educational programmes, the Kirkpatrick's model outlines four levels of evaluation: 1) participants' reaction to training; 2) learning and knowledge improvement, 3) students' behavioural change and adaptation of acquired knowledge in practice, and the last level – 4) results (Heydari et al., 2019).

Khan et al. (2023) discussed the use of the Kirkpatrick's model in the evaluation of cybersecurity training. The authors in their study provided results for three levels of Kirkpatrick's model. For reaction as level 1 in the Kirkpatrick's model, a satisfaction survey was used, while for level 2 and 3 – learning and behaviour – pre-test and post-test results were used (Khan et al., 2023).

The Kirkpatrick's model is used not only to evaluate medical or healthcare training programmes (Heydari et al., 2019; Ghasemi et al., 2020) but also for different trainings such as flight attendant training programme (Gultom et al., 2021), training programmes for head teachers (Alsalamah & Callinan, 2021) or teacher training courses (Mahmoodi et al., 2019).

As the Kirkpatrick's model is widely used to measure different training programmes, it is also suitable for use in the academic context (Alsalamah & Callinan, 2021; Cahapay, 2021). Cahapay (2021) discusses the suitability and tendencies of Kirkpatrick's model in HE, as well as its limitations. The author outlines that the Kirkpatrick's model is mainly limited to use of levels 1 and 2 in HE. Higher levels of the model (behavioural and results/outcomes) should be assessed when the students are in the workplace. Therefore the measurement of these levels should be redesigned in the context of HE (Cahapay, 2021).

Summarising the reviewed related works showed, the necessity of applying appropriate models, such as the Kirkpatrick's model, in measuring the effectiveness and efficiency of HE study programmes has been demonstrated in order to contribute to the training of competitive specialists, to address digital transformation by developing digital readiness of HEI, and to increase students' employment opportunities. Consequently, the next section of this paper presents the use of the Kirkpatrick's model (i.e., limited to levels 1 and 2) for the effectiveness of the implementation of the RAD skills course at VILNIUS TECH.

3. The RAD course implementation and evaluation

The consortium of the Erasmus+ RAD-Skills project decided to develop two modules to teach RAD skills to students from 5 partner universities: VILNIUS TECH, TU Dublin, TalTech, RTU and UNIRI, in close cooperation with the Oracle Corporation.

Cooperation with the Oracle Corporation provided the necessary RAD tool for application development – Oracle APEX LCDP. Therefore, the course material was based on learning methods, materials and tools provided by Oracle Academy. As a result, free access to Oracle APEX was provided by Oracle Corporation as part of the training and hands-on practice in the cloud.

The project consortium has discussed how the RAD course can be introduced in all partner universities. The decision was made to develop two modules. The first one provides the fundamental knowledge of databases and is meant for not only students in computer science, but also for those who have no previous knowledge at all in information technologies. The advanced level of knowledge has been introduced in an intermediate course called Module 2. The content of the courses was agreed by the project consortium and adapted by each participating university in its own language. Each module is worth 3 ECTS. The focus in this paper is only on the first module (Module 1) that consists of basic topics:

- Introduction to Databases;
- Relational Databases;
- Introduction to SQL;
- Data Modelling.

This module created by the project have been included in the study programmes of *Information Systems* and *Software Engineering* at VILNIUS TECH. These study programmes already had the *Databases* (*with coursework*) course in their curriculum, so the necessary topics of RAD skills were included in the existing one. This course is taught in the 4th semester, i.e., in the second year of study.

The course was evaluated using the Kirkpatrick's model. The first level "Reaction" is measured by a satisfaction survey consisting of 7 questions with five possible answers (*Strongly*

Disagree (1), *Somewhat Disagree* (2), *Neither Agree nor Disagree* (3), *Somewhat Agree* (4), and *Strong Agree* (5)) as follows:

- Q1. I was satisfied with the course overall.
- Q2. This course enhanced my knowledge of the subject matter.
- Q3. The course was relevant to what I might be expected to develop rapid applications/a need to develop applications rapidly.
- Q4. This course provided content that is relevant to my daily job.
- Q5. This course provided delivery methods and materials appropriately.
- Q6. I would recommend this course to others.
- Q7. This course acted as a motivator towards further learning.

Level 2 "Learning" of the Kirkpatrick's model was determined by means of a pre-test and a post-test. Students were asked to take a test before starting the course module. At the end of the course, the same students were given the same test for the second time. The results of both tests were compared to determine the learning effectiveness.

A pre-test and post-test question bank was created based on the 36 existing Oracle Apex questions from different topics included in the created modules. The number of questions in each category and an example of the question text are given in Table 1.

Table 1. Number of questions in each topic category and sample question

Topic	Number of questions	Example of question	Possible answers (correct answer is bolded)
Introduction to Databases	3	Which is the first step in the Database Development Process?	Design; **Strategy and Analysis;** Build; Testing
Relational Databases	7	In a relational database a table is referred to as ...	A unique identifier; **A basic storage structure;** An attribute; None of the above
Data Modelling	15	A table is in 2NF if	It meets the requirements for the 1 NF; Each non-key attribute is fully functional dependent on the table's primary key; **Both A and B must be true**; Neither A or B must be true
Introduction to SQL	11	To see all the fields and records in a table you can run the following query:	"SELECT all FROM employees;" "SELECT columns FROM employees;" "SELECT * FROM employees;" "SELECT # FROM employees" None of the above.

Both the pre-test and the post-test consisted of 19 questions randomly selected from a question bank. The type of question was either multiple choice or true/false.

The collected answers were tabulated and compared applying paired t-test, as presented in (Mahmoodi et al., 2019; Heydari et al., 2019).

4. Results

The satisfaction survey was completed by 33 students: 8 students from the *Information Systems* programme and 25 students from the *Software Engineering* programme. Overall, the number of responses is sufficient to draw some conclusions about the students' feedback on the course.

The detailed number of responses to each question is shown in Table 2. As can be seen from the table, more than half of responses (59.83%) were *Somewhat Agree* (33.62%) or *Strong Agree* (26.20%).

A visual representation of the survey results is shown in Figure 1. Table 1 and Figure 1 show that 70% of participants were satisfied with the course overall, 76% agreed that this course increased their knowledge of the subject matter, 63% agreed that the course was relevant to what they might expect from RAD, 61% agreed that the course provided appropriate delivery methods and materials, 61% would recommend this course to others, and for 53% of participants this course acted as a motivator for further learning.

The next step was to determine the learning results and how the students' knowledge had improved. A total of 40 students participated in the knowledge test before learning Module 1: 12 students were studying *Information Systems* and 28 students were studying *Software Engineering*. A total of 42 students participated in the knowledge test after learning Module 1: 8 students were studying *Information Systems* and 34 students were studying *Software Engineering*.

Table 2. Satisfaction survey responses

Questions No. / Answers	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Percent
Strongly Disagree (1)	3	2	2	4	2	4	4	9.17
Somewhat Disagree (2)	0	2	1	7	3	2	4	8.30
Neither Agree nor Disagree (3)	7	4	9	10	8	7	7	22.71
Somewhat Agree (4)	18	8	10	10	12	11	8	33.62
Strong Agree (5)	5	17	10	2	8	9	9	26.20

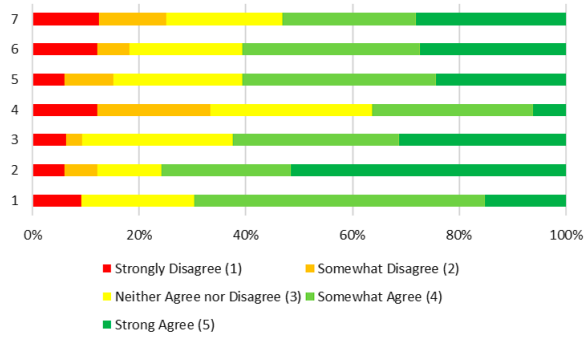

Figure 1. Satisfaction survey results for Module 1

The distribution of scores obtained by students in the Level 2 "Learning" test is shown in Figure 2. The blue columns in this diagram represent the result of the test that has been taken before learning Module 1, while the orange ones – the results after the module has been taken. The overall points have been divided into four groups:

1) students who failed the test with point in the range [0; 4.8);
2) students who have satisfactory knowledge ranging in [4.8; 7.4);
3) students having typical knowledge scoring in the range [7.4; 8.4);
4) students with great knowledge [8.4; 10].

As it can be seen, the majority of students scored less than 7 in the test before taking Module 1. The increase in the number of students who scored more points after Module 1 can be seen.

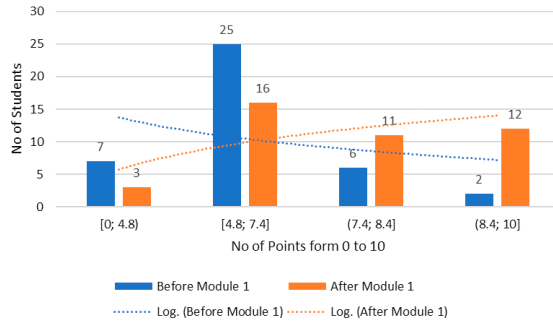

Figure 2. Learning survey results for Module 1

The results of the test according to the different topic of the module are shown in Figure 3. Red colour represents the wrong answers to the questions while the correct answers are showed in green colour.

Figure 3a shows the answers from the pre-test. It can be seen that half or more of the students did not answer the questions correctly. The topic of *Relational Databases* stands out in this figure as the one with the most wrong answers.

Figure 3b shows the post-test responses. The increase in the correct answers can be seen in this case. Although the results improved in all topics, the most significant increase can be seen in the topic *Relational Databases*.

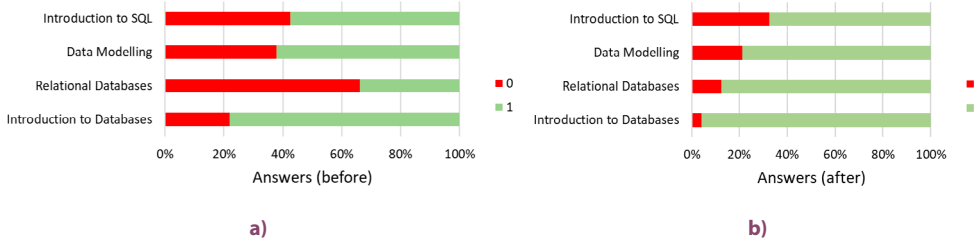

Figure 3. The results of tests for Module 1 according to topics: a – the results of the pre-test; b – the results of the post-test

Table 3. Paired sample T-test, students' results of the pre-test and the post-test

Attributes	Values
Variance	1.6769
DF	79
t Stat	–3.7964
P(T ≤ t) two-tail	0.000286581
t Critical two-tail	1.99045021

The result of the paired sample t-test (see Table 3) shows a statistically significant difference in the students' knowledge before and after attending the RAD skills course ($t(79) = -3.7964$, $p \leq 0.01$). Thus, students achieved better performance on the post-test.

5. Conclusions

The analysis of related work shows the importance of evaluating courses and training. Not only does it help to improve the course itself, but it also allows for the personal growth of the participants. Although there are many methods available to evaluate training, the Kirkpatrick's model is the most commonly used. Although this model is more difficult to adapt in HE at higher levels (i.e., Level 3 "Behaviour" and Level 4 "Results"), it can be easily applied at the lowest levels (i.e., Level 1 "Reaction" and Level 2 "Learning").

The paper explained how a course introducing RAD within the *Databases* (*with course-work*) course was created and implemented at VILNIUS TECH. The results of the survey to get feedback from students showed that more than half (59.83%) were satisfied with the course.

Students with typical knowledge increased about 73% after this course. The increase of students showing great knowledge is 6 times. The results of the test prove that students after this module have learned new RAD software development skills and improved their knowledge.

Although the presented results prove that the course has been implemented successfully, the further analysis to investigate the results behind separate topics of the Module 1 should be carried out. New ways to improve the course have also been identified as a future work, as follows: 1) improving some topics, 2) improving some questions, 3) improving some teaching methods and materials.

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