eISSN 2783-6851

VILNIUS TECH
Vilnius Gediminas Technical University

NEW TRENDS in COMPUTER SCIENCES

2024
Volume 2
Issue 1
Pages 69–80
https://doi.org/10.3846/ntcs.2024.21227

INTRODUCING RAPID WEB APPLICATION DEVELOPMENT WITH ORACLE APEX TO STUDENTS OF HIGHER EDUCATION

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Article History:
- received 27 March 2024
- accepted 6 August 2024

Abstract. The rapid development of information and communication technologies (ICT), and enforcement of digital transformation have caused the need to develop and deliver software in even shorter time than previously, and has become crucial to businesses. Yet, this new need has caused a challenge of finding expert IT workforce able to deliver software applications due expected time. Moreover, in a rapidly changing business world, the traditional software development can no longer keep pace and provide solutions to businesses fast enough. Low-code development and inclusion of so-called citizen developers are seen as a solution for the problem. This paper explores the introduction of rapid application development courses on Oracle APEX technology to students of a European technological university. The paper discusses the implementation of the course and its design, and looks how the developed basic-level course was received by students. It is shown that the courses have been well-received by students, who based on provided feedback are satisfied with the online set up for self-regulated learning of rapid application development skills.

Keywords: rapid application development, low-code, Oracle APEX, higher education, web applications, databases.

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1. Introduction

With the rapid development of information and communication technologies (ICT), and digital transformation, the need to develop software and do it fast has significantly grown. This on the other hand has caused several problems, including the lack of expert workforce. The need to rapidly develop software has become essential for businesses, as being late to market a product could mean being out of the business due to heavy competition. Moreover, digital transformation (Mergel et al., 2019; Vial, 2019) goes far beyond of just merely digitizing existing content (Yoo et al., 2010) and processes, feeding the 'hunger' for IT solutions, platforms, and apps from end-users and general public eager to communicate and solve their everyday problems via digital platforms. In a rapidly changing business world, where requirements can change drastically even overnight, traditional software development can no longer keep pace and provide solutions to businesses quickly enough, and another kind of approach is needed.

Here, low-code development and low-code development platforms (LCDP) are seen as a solution, filling the gap between business needs and IT, and enabling even non-technical experts (also called as "*citizen developers*") to develop software, addressing specific business needs. Low-code development platforms are easy to use graphical environments allowing everyone regardless of their coding skills to develop and deploy fully functional software

applications (Sahay et al., 2020; Waszkowski, 2019). Several LCDPs from many vendors are available today on the market – for example Microsoft Power Apps, Google App Maker, Mendix from Siemens, Honeycode from Amazon, or Oracle Application Express (APEX), the latter being in the focus in this paper.

Although LCDPs require little or no coding skills, to be able to advantage from such platforms, training is still needed, in order to understand how they function, what features do they provide, how to handle data, etc. Thus, to find solutions to the shortage of skilled ICT specialists, on top of providing LCDPs, we need to educate and train potential low-code developers for their advanced digital skills and rapid application development (RAD). The current paper addresses exactly the aforementioned problem and discusses the usage of Oracle APEX LCDP to teach students of higher education (HE) on bachelor level (but not limited) the foundations of RAD.

In 2022, a consortium of five European universities: 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, was formed to implement Erasmus+ HE cooperation project KA220-HED-E99B8F14 "*Embracing rapid application development* (*RAD*) *skills opportunity as a catalyst for employability and innovation*". The objective of the project was set to deliver knowledge of RAD skills in a similar way to the students of these universities and beyond, and prepare young talents for the job market. To achieve these goals, the project includes activities such as development of two courses (modules) for delivering knowledge and skills needed for RAD specifically targeting Oracle APEX LCDP, workshops and local roundtables bringing together students, representatives from business and HE representatives interested in rapid application development, and offering of practice places in industry on Oracle APEX LCDP for students. The project is implemented in cooperation with the Oracle Corporation, which provides free access to Oracle Cloud Infrastructure (OCI) for teachers and students, and supports the activities of the teachers through Oracle Academy, including teacher training.

In this paper, we discuss how we implemented the courses for delivering RAD knowledge and skills to HE students at TalTech using Oracle APEX, and how were these courses accepted by students. As at the time of writing this paper, TalTech is on its eighth study week out of the 16-week long semester of active teaching, we can only report intermediate results. Specifically, we focus on the following research questions:

- RQ1: How were the courses to teach RAD skills set up at TalTech?
- RQ2: How has the RAD skills foundational course been received by students?
- RQ3: How easy it has been for students to access OCI and APEX?

We show that the courses have been well-received by students, and students in general are quite satisfied with the online set up of the courses and the remote learning on the concept of self-regulated learning (SRL).

The rest of the paper is structured as follows. In Section 2, we briefly discuss related work, in Section 3 we describe the course setup at TalTech, answering the first research question. Section 4 focuses on the reception of the foundational course by students. In Section 5, we discuss how easy it has been for students to access Oracle cloud infrastructure and application express. In Section 6, we draw conclusions.

2. Related work

Although a lot of publications on low-code implementation and its technical aspects exist for the software engineering domain, and have gained focus lately, the academic side and especially the higher education context has received little attention, and only a limited number of works are available. The work of Khorram et al. (2020) has explored how to alleviate the shortage of IT-experts through the use of LCDPs and citizen developers, and Sanchis et al. (2020) how low-code platforms will enable digital transformation. Käss et al. (2023) explored the drivers and inhibitors for low-code development platform adoption and their importance from the practitioners' perception, and identified 12 drivers and 19 inhibitors for adopting LCDPs.

In higher education, Juhás et al. (2023) explored an alternative to the traditional causal flow of IT education using a top-down approach for Petriflow-based description of processes for low-code language education. Yet, there are only a few papers addressing Oracle APEX technology. Bento et al. (2022) studied the applicability of Oracle Application Express for IoT projects, showing the viability of APEX for remote solutions. Kvet (2024) discusses the latest Oracle Database 23c update to enable Update and Delete operations in the context of the Erasmus+ HE project BeeAPEX. While this paper focuses on the data layer of APEX, another paper by Pastierik and Kvet (2023) explores teaching of web software development for technical and non-technical students using Oracle Application Express low-code platform. The authors find, through their teaching practice, that Oracle APEX is a perfect solution for teaching web application development. While the paper by Pastierik and Kvet (2023) mostly focuses on describing the features of Oracle APEX and the potential principles for teaching software development using APEX as a medium, our work complements their work on the use of Oracle APEX in HE to better align with university graduates preparedness for their job market, and specifically contributes by describing a course structure and path for online self-regulated learning of RAD skills.

Self-regulated learning (SRL) (Jossberger et al., 2020; S. G. Paris & A. H. Paris, 2001; Zimmerman, 2000) is a proactive approach, where students take their initiative in their learning process, and is found critical for enhancing student engagement and learning outcomes (Russell et al., 2022; Zheng & Li, 2016). Our RAD skills course setup builds upon SRL strategy, and could even be extended for life-long learning (Ifenthaler, 2012; Taranto & Buchanan, 2020), i.e., for training new citizen developers and people obtaining additional skills outside the IT industry on top of their existing education. Self-regulated and life-long learning concepts are highly important in ICT training, where constant changes in technology and available tools take place.

On the side of aligning industry needs to academic teaching practices, the work of Metrôlho et al. (2022) investigated how to enhance students' preparedness for software industry's job market. In their work, they included IT professionals into students' projects to reduce the gap between academic education and industry needs, showing this approach to be effective. For carrying out the projects, they used the Scrum methodology for project management and OutSystems LCDP for solution development.

We build our work on previous research and expertise on improving students learning gain on MOOC platforms (Robal et al., 2018; Zhao et al., 2018), which are known to suffer from high drop-out (Eriksson et al., 2017), individualized evaluation of teamwork tasks (Robal, 2018) and overcoming sudden challenges in teaching on the example of the recent pandemics (Ruberg et al., 2022), which forced everyone to online mode. Here, we use this gained expertise to provide valuable engineering education for teaching RAD skills.

3. Teaching RAD skills at TalTech

To answer the first research question (RQ1), we start by discussing the project consortium, followed by a description of the courses at TalTech and the course design for TalTech students. The project consortium decided to develop two modules for teaching rapid application development skills for students of the partnering universities. Specifically, the basic level knowledge is transferred as the foundational course (labelled as Module 1), and the advance level knowledge as intermediate course (Module 2). The LCDP in use is the Oracle APEX running on Oracle OCI. Each partnering university had the obligation to implement both modules, except UNIRI, who implemented only Module 1. Through several discussions and careful planning, course topics were selected for both modules. It was decided to rely on and re-use the concepts available in the course materials provided by the Oracle Academy as the basis for Module 1 and Module 2 development, considering also local restrictions and expectations, leaving thereby freedom of implementation for each partnering university (e.g., inclusion of additional topics). In summary, at TalTech we used the materials provided by Oracle Academy as the basis and the source of concepts for consortium-agreed course content. Yet, we customised and supplemented the course topics with additional sources and examples delivered by TalTech expert teachers, and developed a new course flow particularly suitable for TalTech students and SRL online learning when developing these novel courses.

3.1. Courses at TalTech

At TalTech, two different courses were established to implement Modules 1 and 2: IXX0301 Foundations of Rapid Web Application Development (3 ECTS) with pass/fail assessment, and IXX0303 Rapid Application Development for Web (6 ECTS) ending with an exam, correspondingly. Both of the courses were offered in Estonian language (as required by the project conditions) and university-wide for bachelor level students, although not limited, on spring semester 2024. The courses were designed in a way that they started to run at the same time, and thus Module 1 is common for both – students taking only the 3 ECTS course and students taking the intermediate course of 6 credits (Figure 1). The foundational course (Module 1) lasts for eight weeks, whereas the students interested in gaining intermediate level knowledge, can immediately declare a 6 ECTS course, containing both modules and lasting for 16 weeks.

Once the courses were developed, we implemented them on the university's Moodle Learning Management System (LMS). At the beginning of the course, an introductory face-to-face meeting was held with students, introducing the novel course on RAD skills, and the

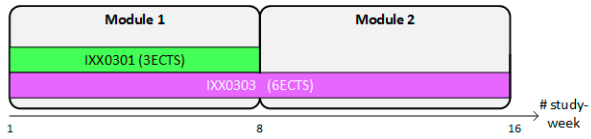

Figure 1. Implementation of Modules 1 and 2 into courses at TalTech. Courses

conditions of the course. After this, students interested in the topics could declare either of the courses: IXX0301 or IXX0303 in their study plan for spring semester 2024. We received 31 declarations for the foundational course (IXX0301) and 35 students for the intermediate course (IXX0303). Out of these 65 students (one student declared both courses, which was not allowed) 61 signed up for the course on TalTech Moodle, however only 54 (83%) of them started with course activities. This is quite expectable, as the courses were provided as free elective, i.e., free to study without any fee or obligation to complete for students. Free elective learning at TalTech is a part of each curricula, into which students can choose courses on their free choice; yet these courses are not considered to be a part of the curriculum but rather carry the value of obtaining knowledge and skills otherwise not covered by the curricula but seen of value by students. Therefore, SRL in online form is an appropriate choice for course implementation. We expected that the courses would be taken by students interested in rapid application development or Oracle technologies, including Oracle APEX.

3.2. Course design

While the implementation of Module 1 focuses on "citizen developers" (all students regardless of their curriculum) skills, Module 2 has a strong focus towards IT experts (students of the information technologies curricula), and as an intermediate course goes deeper into several topics. The topics of Module 1, as selected by the consortium, include basics of databases, data representation and modelling essentials, introduction to APEX LCDP and ends up with a project, where students practice developing an APEX-based web application to represent existing data (e.g., from spreadsheets) and simpler queries in Structured Query Language (SQL) for data reporting. This is achieved by the use of wizards included in Oracle APEX, and the tasks in the module are suitable for citizen developers. The topics of Module 2 include deeper understanding of the relational database model and its normalization up to the third normal form, complex queries in SQL, and application of the APEX LCDP for data handling, collection, manipulation and delivery. Module 2 has a strong focus on Web application development with APEX and ends with development of a data-intensive Web application as a project, where students have to be in charge of the implementation instead of the use of wizards. Table 1 provides overview of the topics in Modules 1 and 2 as implemented for the TalTech courses.

All the course materials and tasks for TalTech courses were developed from scratch and are delivered through Moodle LMS. For our RAD skills courses at TalTech, we decided to use self-regulated learning strategy (S. G. Paris & A. H. Paris, 2001; Zimmerman, 2000) known for enhancing student engagement and learning outcomes (Russell et al., 2022; Zheng & Li, 2016), and provide Modules 1 and 2 as online courses on Moodle LMS. The theoretical

Table 1. Topics of the foundational (Module 1) and intermediate (Module 2) course as implemented on TalTech Moodle LMS.

Module 1	Module 2
1. Introduction to Module 1 2. Introduction to databases 3. Relational databases 4. Database normalisation (overview) and terminology 5. Data modelling 6. Physical data model 7. Access to Oracle APEX environment 8. Structured Query Language (SQL): Introduction 9. App development in APEX (wizard level)	1. Introduction to Module 2 2. APEX course project 3. Data normalisation (3NF) 4. Structured Query Language (SQL) 5. App building in APEX: pages and reports 6. App building in APEX: forms 7. App building in APEX: navigation and styles

materials are delivered for students as videos and slides – providing students an option of either watching videos or using slides, or both, to familiarize with the theory. The theory is complemented with automated self-tests implemented on Moodle LMS, which students are required to perform and pass with a threshold of at least 70%. The tests are limited in attempts. In the designed course flow, once students have obtained theoretical knowledge and passed the tests, they are advised to proceed to perform practical tasks. Practical tasks are provided both on Moodle LMS and on Oracle APEX (e.g., the SQL Workshop included in Oracle APEX). As much as possible, we have automated the practical tasks to smoothen the course flow for students – any task that needs to be manually checked by instructors means in average a few days up to a week of waiting, which may be demotivating for SRL online learners who want to obtain knowledge fast. Practical tasks on SQL concepts (e.g., SELECT queries) were automated with the exploitation of the Moodle CodeRunner plugin. For tasks performed in the Oracle SQL Workshop, students had to acquire input data from Moodle, implement scenarios in Oracle SQL Workshop, and report the results back in Moodle, where a special test form was used, allowing partial automation of the results. For the first implementation and run of the courses, TalTech expert teachers were used to validate the course, tasks, and settings. However, for future runs, we have planned to include teaching assistants for the already validated tasks.

For each topic students perform, we also ask them to provide feedback. The feedback is collected through specific feedback form, where students are requested to evaluate different aspects of the topic and their learning gain (self-reflect) but also are able to provide free-form textual comments. This course activity is part of each topic and is made compulsory. We collect this feedback to understand students' learning process, and to further improve our courses.

Based on this course design, a general course flow was established, and then customized for Module 2 (for project-based approach). Figure 2 depicts as a "metro"-diagram the established and recommended course flow for students of Module 1, where large circles represent transfer to another topic. The flow given as "metro"-diagram follows the exact description previously given. To disallow students to transfer from one "topic-station" to another, we have implemented restrictions in Moodle that feedback on already completed topic must be given before a theory test on the next topic can be taken, and to be able to provide topic

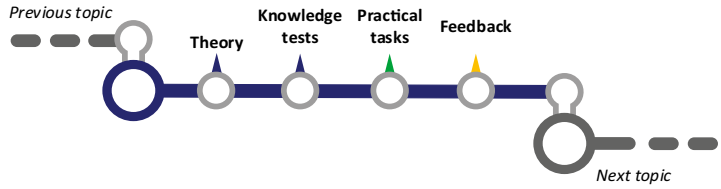

Figure 2. A "metro"-diagram depicting the typical course flow and implementation for the foundational course (Module 1)

feedback, practical tasks need to be accomplished with a pass result. In this way, we ensure that students will progress through topics in a needed and pre-programmed order, without introducing gaps in their learning gain.

For the intermediate course (Module 2), we customized the course flow (Figure 3). As Module 2 ends with a web application project, some of the practices were transferred to be a part of the course project implementation. Namely, with the first topic in Module 2, students already start doing the course project by selecting the business use case for which their project solution is going to satisfy business needs. The course project runs in parallel with other topics, which of some have practical tasks on the main track (as described on Figure 2 and Figure 3 in blue), e.g., practical tasks on SQL and data manipulation. In this way, the course module flow supports the delivery of a Web application project, and students are able to see and track their project's logical development through several stages. We may observe from Figure 3 the "intermediate stops" for the project starting from selecting the business use case to be solved, establishing the underlying data model and database for the solution, and then proceeding to develop the application on the APEX platform. The Module 2 ends with the delivery of the course project.

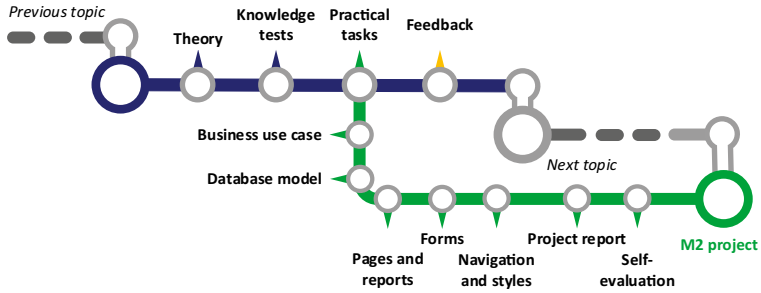

Figure 3. A "metro"-diagram depicting the course flow for the intermediate RAD skills course (Module 2)

4. Reception of the foundational course

To answer the second research question (RQ2) on how have the courses been received by TalTech students, we investigate the feedback students have provided for each of the topics of Module 1 regarding the course materials. Do recall that this study is limited to Module 1

only (running academic weeks 1–8), as stated in the Introduction. The course materials were compiled based on the original Oracle Academy training materials we were allowed to use, and which we included as an input for course topics and structure development.

As discussed in Section 3.2, each topic was equipped with feedback module, where students were asked to provide their insights into the topic for course improvement. One of the feedback questions was: "*Please evaluate how clear and understandable were the provided materials* (*videos and slides*)". Students were asked to provide the feedback on a 5-level *Likert* scale as follows: *Very easy*, *Easy*, *Moderate*, *Difficult*, and *Very difficult*. In addition, they could leave their comments in free form for the whole topic. We now use this feedback to analyze how did students receive the foundational course. We analyze the ratings given by correspondents proportionally, and whenever textual comments are present for topic feedback, investigate if there are positive or negative comments connected to the feedback question. On one hand, relying on our practice, we know that students tend to be critical towards materials, and if they are not satisfied with the results materials and instructors are to be blamed. As for the RAD courses we have opted for SRL in online mode, the contact with instructors can be excluded from this. On the other hand, the perceived difficulty of materials reflects students' prior knowledge and expectations, and the level of novelty delivered by materials.

The responses from Module 1 participants (Figure 4) reflect that the foundational course is well received. In average, 33 students corresponded, although we see that topic-wise there is a decreasing trend in answering. Partially, it is due the course module still running and students have not yet completed all the topics, but also due to some students dropping the course. The majority of students evaluate the materials to be easy to comprehend, whilst the most difficult part is the most novel topic for them – application development in APEX. In the written feedback, we did not collect as many answers as for the obligatory scaled questions but some students decided to share their thoughts with us.

There were positive notes, such as: "*The course seems interesting. It is relevant and important to know how databases prove useful in business and life.*", or "*The given topic was easy to understand, the necessary knowledge and skills were quickly acquired by watching the slides together with the videos, which made the practical work passable with little effort*" but also

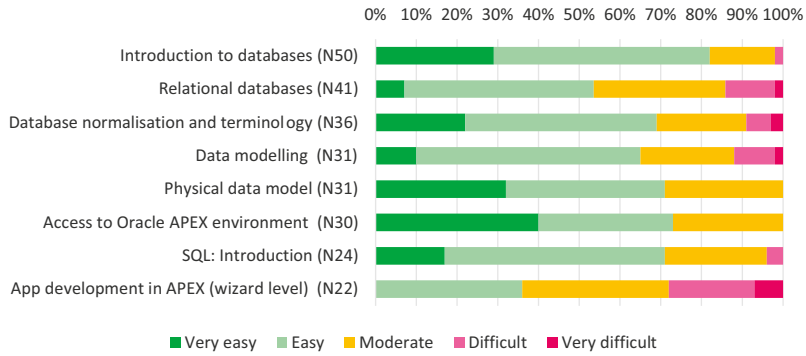

Figure 4. Comprehensibility and satisfaction with course materials for topics of Module 1 of the RAD skills course (the number in parentheses indicates the number of correspondents)

negative remarks, such as one of the respondents was very disappointed that in the course design we had implemented penalties: "*24h pause time for failed tests is too much, in real life I do not go through the materials of the topic 24 hours*".

Some students complained that they did not find slides, although these were present for each topic together with video materials. This might have been due to the latest changes in the graphical user interface of the university's Moodle (transfer from version 3 to version 4), where the layout of courses was changed. For example, a major disadvantage that was introduced is the inability for an instructor to indent content in course view, thus the loss of structure, as everything is represented vertically on the same line, or then individual readability and usability issues of the LMS.

Based on the provided feedback and freeform comments provided by participants, we conclude that students accept the course and its SRL online format for the foundational part. As the courses are still running, it would be interesting to see, if the intermediate course (Module 2) is received the same, or it proves to be more sophisticated for the 35 students who chose it. The latter, however, remains a future work.

5. APEX for the foundational course

Last, to address RQ3, we look at how easy it has been for students to access OCI and APEX. For this, we specifically look at the student feedback given for the course topic "*Access to Oracle Apex environment*" in Module 1 (Table 1), which discusses how to access OCI and APEX platforms. Complementary, we also rely on immediate feedback we have received from students through course support forum on Moodle LMS.

Based on the feedback provided by 32 students, we see that the vast majority (73%) of students have found the instructions and access to OCI and APEX easy, whilst almost one third have evaluated it to be moderately difficult (27%). The majority (51%) of responses on topic novelty highlight the content was new to students. In the voluntary part of the topic feedback form, we do not find any negative comments nor notes on problems.

Yet, from the immediate feedback provided through course support forum, we collect the knowledge that at least 10% of students have had some sort of a problem either with logging in to OCI or being unable to access the resources once completed the sign-up process. Indeed, to handle the whole access package, one needs to obtain OCI cloud user space, username and password, yet another set of credentials for APEX instance, etc. This is confusing not only for students but also for teachers who have gone through the Oracle Academy training, as we learned during our weekly meetings when developing the courses. From the educational point of view, the path on orientating around these resources is not easy, although, from infrastructure, security and application point of view, this separation of concerns is highly justified. The access problem could be somewhat overcome with more comprehensive and structured explanations, which we have now as a response developed for the course with graphical illustrations. Yet, technical faults on the OCI side (e.g., a student account is ordered by instructors but the registration fails for a student) cannot be solved by the teachers. In a few cases, the students opted to register as regular users of OCI using their own credit cards (not a necessity with student accounts), as fault identification and solving

took long and valuable time on learning was lost. This calls for an updated administration interface for instructors on the Oracle Academy side, through which the accounts are ordered.

Considering both, the immediate feedback from course forum as well as the specific feedback collected for the APEX access topic, we conclude that for the first-timers the access procedures for OCI resources can be challenging, and it requires habituation and understanding of the actual processes happening behind. Yet, from the feedback we also learn that once students gasp how APEX and OCI work, they do not find it difficult anymore. From educational point of view, this "hard start" may lower the motivation of learners and prolong the learning path, which can be relieved by additional instructions. The technical faults, which solving is beyond the capabilities of the instructors, are however a liability of the service provider, and a reality students must also learn when working with cloud environments for Platform as a Service (PaaS) and Software as a Service (SaaS).

6. Conclusions

In the rapidly changing business world with a constant drive for improved digitalization, we are facing two underlying problems – a lack of IT experts for software development, and an inability to deliver software as fast as businesses would require. A solution is seen in low-code and no-code development platforms, where through the use of graphical user interfaces everyone is able to develop software easily and in due time.

In this paper, we explored how rapid application development courses exploiting Oracle Application Express (APEX) technology were introduced to ICT students of Tallinn University of Technology (TalTech). These courses were established as a part of the RAD-Skills project implementation. The paper discusses the courses' design, allocation of topics to modules and design of learning paths through topic activities for self-regulated online learning. Using an existing running course instance, we investigated the course uptake by learners, and the problems the students encountered. Through students' feedback, we learned that the foundational level course, delivering the basic knowledge for citizen developers, was received well and was found interesting and actual by students. There were no major obstacles on the established learning path, except technical issues with cloud platform access. The extensive support by Oracle Academy in the form of providing free access to OCI and training for the teachers has been valuable in setting up the courses. In summary, we conclude that RAD skills, delivered on the foundational level, are valued by students, and the established course design on the concept of self-regulated learning has worked well to deliver the knowledge and skills on rapid application development to students interested in the topic.

In terms of future work, we continue with the RAD skills course Module 2 to collect performance data and enhance teaching of rapid application development.

Acknowledgements

This research was supported by the Erasmus+ EU programme for education, training, youth and sport KA220-HED project Embracing rapid application development (RAD) skills opportunity as a catalyst for employability and innovation co-funded by the European Union.

Funding

This work was supported by the European Commission under Grant KA220-HED-E99B8F14.

Author contributions

Tarmo Robal and Uljana Reinsalu were responsible for the design of the study, data analysis, and writing the manuscript.

Lembit Jürimägi and Risto Heinsar were responsible for the study implementation and data analysis.

Disclosure statement

The authors have no competing interests to declare that are relevant to the content of this article.

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