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Formative Assessment Activities to Advance Education: A Case Study

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Abstract

Aim/Purpose	During the education of future engineers and experts in the field of computer science and information communication technology, the achievement of learning outcomes related to different levels of cognitive ability and knowledge dimensions can be a challenge.
Background	Teachers need to design an appropriate set of activities for students and combine theory-based knowledge acquisition with practical training in technical skills. Including various activities for formative assessment during the course can positively affect students' motivation for learning and ensure appropriate and timely feedback that will guide students in further learning.
Methodology	The aim of the research presented in this paper is to propose an approach for course delivery in the field of software engineering and to determine whether the use of the approach increases student's academic achievement. Using the proposed approach, the course Process Modeling for undergraduate students was redesigned and experimental study was conducted. Course results of the students (N=82) who took the new version of the course (experimental group) were compared to the results of the students from the control group (N=66).
Contribution	An approach for a blended learning course in the field of software engineering was developed. This approach is based on the formative assessment activities that promote collaboration and the use of digital tools. Newly designed activities are used to encourage a greater level of acquired theoretical content and enhance the acquisition of subject-specific skills needed for practical tasks.

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Findings The results showed that students who participated in the formative assessment activities achieved significantly better results. They had significantly higher scores in the main components of assessment compared to the students from the control group. In addition, students from the experimental group expressed positive views about the effectiveness of the used approach.

Recommendations for Practitioners The proposed approach has potential to increase students' motivation and academic achievements so practitioners should consider to apply it in their own context.

Recommendations for Researchers Researchers are encouraged to conduct additional studies to explore the effectiveness of the approach with different courses and participants as well as to provide further insights regarding its applicability and acceptance by students.

Impact on Society The paper provides an approach and an example of good practice that may be beneficial for the university teachers in the field of computer science, information-communication technology, and engineering.

Future Research In the future, face-to-face activities will be adapted for performance in an online environment. Future work will also include a research on the possibilities of personalization of activities in accordance with the students' characteristics.

Keywords assessment, collaborative learning, course design, digital tools, process modeling

INTRODUCTION

Improving the education process represents a constant challenge for educators and researchers in all areas of learning, including the fields of computer science, information-communication technology (ICT), and engineering. Although future engineers should acquire scientific facts and theories to successfully apply them into technical artifacts or technological systems, they also need specific and practical knowledge or training in various technical skills such as drawing, modeling, programming, designing or similar (Semerikov et al., 2020; Telegin et al., 2019). This need is emphasized by the so-called market-driven approach, according to which the education of future professionals in the field of engineering is often in direct connection with business firms. When using this approach, a real-world environment is simulated during the learning process (Beard et al., 2010; Fagerholm et al., 2017; Tuya & Garcia-Fanjul, 1999). Additionally, general or supportive skills necessary for future engineers such as communication and social skills, teamwork, creativity and critical thinking should not be ignored (Blom & Saeki, 2012; Borrego et al., 2013; Silva & Araujo, 2012).

To facilitate acquisition of knowledge and skills during the teaching process, teachers organize learning activities. These represent interaction of students with a learning environment comprised of teaching materials and tools that support learning (Aljawarneh, 2020; Beetham & Sharpe, 2007; Gasca-Hurtado et al., 2019). When combining face-to-face and online teaching, a fundamental constituent of the learning infrastructure is often a learning management system (LMS) that enables the delivery of teaching materials, communication among teachers and students, knowledge assessment, but also the realization of learning activities (Islam & Azad, 2015). However, the limitation of these systems is that they often do not include the tools necessary to practice specific skills for a specific area (Alario Hoyos et al., 2013; Meccawy et al., 2008) so other digital tools (also referred as Web 2.0 tools) can be used as an alternative (Can et al., 2019; Hoic-Bozic et al., 2016; Oliveira & Moreira, 2010; Orehovački et al., 2012).

Learning activities are focused on learning outcomes and occur in response to a specific task (Beetham & Sharpe, 2007). According to the revised Bloom's taxonomy, learning objectives can then relate to a lower or higher level of cognitive ability as well as various knowledge dimensions. For education in the field of computer science, ICT and engineering, all hierarchical levels of cognitive ability are important (remembering, understanding, applying, analyzing, evaluating and creating) as well as knowledge dimensions (factual, conceptual, procedural and metacognitive knowledge) included in the revised Bloom's taxonomy (Krathwohl, 2002). Modern approaches to teaching emphasize the importance of applying the constructivistic theory of learning, especially for reaching the learning outcomes related to the higher levels of cognitive ability as well as cognitive and procedural knowledge dimensions. Learning according to the constructivistic theory should be combined with project-based and problem-based learning (Litzinger et al., 2011) as well as learning activities that include student interaction and collaboration (Borrego et al., 2013; Dillenbourg, 1999; Willey & Gardner, 2012), which takes place face-to-face or online through collaborative e-learning activities, also called e-tivities (Armellini, & Aiyegbayo, 2010).

To gather evidence of students' achievements of the intended learning outcomes, different methods of knowledge assessment are used. These include oral examinations, paper-based or online tests, but also reports, reviews, journals, e-portfolios, and so forth, which are created as a result of student participation in learning activities. In order to indicate the extent to which students have achieved intended learning outcomes of the whole course or a part of the material covered by the course, summative assessment is used (Crawley et al., 2014). Along with the summative assessment conducted at the end of the instructional event, research suggests benefits of implementing formative assessment (Hassan, 2014; Hernandez, 2012; Limniou & Smith, 2014). Using formative assessment, evidence of student achievement is collected while students are in the process of learning, in order to inform them about their progress. This is the reason why activities which enable formative knowledge assessments should precede those included in summative assessment.

The aim of the research presented in this paper is to propose an approach for course delivery in the field of software engineering, which is based on the introduction of formative knowledge assessment, and to determine whether the use of the approach increases student's academic achievement. The approach introduces a variety of activities for formative knowledge assessment in order for the student to have the opportunity to get feedback on his/her level of achievement. The introduced activities are aligned with the intended learning outcomes from various levels of cognitive ability and knowledge dimensions. Although the emphasis is placed on collaborative learning and the application of digital tools to further advance the development of the skills necessary for future professionals in the field of software engineering, the approach is also applicable for the teaching process of other professions in the field of computer science and ICT.

Using the proposed approach, the course "Process Modeling", which is part of the Computer Science major, was redesigned. It is a course whose content, in the opinion of employers and computer science experts who work in practice, is among the key topics in the education of future engineers and computer scientists (Ahmed et al., 2013; Blom & Saeki, 2012; Frohnhoff, 2008; Moreno, 2012). The application and evaluation of the proposed approach is performed by complementing a series of existing activities of the selected course with new activities for formative knowledge assessment, in accordance with the characteristics of the approach. Course results of the students who took the new version of the course (experimental group) were compared to the results of the students from the control group. Comparison of the results determined that students from the experimental group achieved significantly better results in the key components of summative evaluation which indicates the effectiveness of the used approach.

The rest of the paper is structured as follows: Section 2 gives the background of the study and Section 3 describes methodology. Approach for the e-course "Process Modeling" is presented in Section 4 and includes the description of course content, objectives and grading, course activities for summative assessment as well as new formative assessment activities introduced to advance the course. Section 5 presents results of the implementation. Section 6 brings discussion while Section 7 gives conclusions and plans for future work.

BACKGROUND OF THE STUDY

Formative assessment is an important element of engineering education, with the potential to improve student learning effectiveness (Limniou & Smith, 2014; Nicol & Macfarlane-Dick, 2006; Roselli & Brophy, 2006). Formative assessment is used by teachers and students to recognize and respond to student learning in order to enhance that learning, during the learning process (Bell, & Cowie, 2001). It should be integrated into the interaction between teachers and students in order to provide feedback, regardless of whether there is interaction in face-to-face or online learning environment.

Through the activities of formative assessment, theoretical content, i.e., knowledge of the factual and conceptual knowledge dimensions, is pointed out to students. Factual knowledge refers to the knowledge of basic elements and terminology, while conceptual knowledge also includes understanding of the interrelationships among basic elements within a larger structure (Krathwohl, 2002). It is conceptual knowledge that is a critical element in the development of competence and expertise in engineering and it should preferably be developed at the beginning of the course (Buldu & Buldu, 2010; Montfort et al., 2009; Streveler et al., 2008; Watson et al., 2016). To provide feedback regarding the factual and conceptual knowledge, activities such as paper-based (Newcomer & Steif, 2008; Streveler et al., 2008; Weurlander et al., 2012) or online tests (Bälter et al., 2013; Lin & Lai, 2013; Rutkowski, 2016) can be used. Online discussions that provide insight into whether students correctly interpret courses and provide an opportunity to correct misconceptions, if they exist, can also be of use (Gaytan & McEwen, 2007; Horstmanshof & Brownie, 2013; Vonderwell & Boboc, 2013). In order to visualize and reflect on their knowledge about the relation between key concepts, students can create concept maps (Anohina-Naumeca, 2015; Gary et al., 2012; Tepper, 2014; Watson et al., 2016).

Formative assessment also allows teachers and students an insight into the level of procedural knowledge acquisition. Procedural knowledge includes knowledge of subject-specific skills including various techniques and methods as well as criteria for determining when to apply them (Krathwohl, 2002). Therefore, in designing the activities for formative assessment of skills, it is necessary to take into account the specificities of the subject domain that is being taught.

An important part of education in software engineering is the field of user requirements engineering, which includes elicitation of requirements by using different techniques and building a process model as a result of the conducted analysis (Davey & Parker, 2015; Zowghi & Paryani, 2003). In addition, it is very important that students experience working with clients in order to become familiar with the problems and challenges that analysts of business processes encounter in their jobs (Hogan, & Thomas, 2005). Software development is almost exclusively a team activity and in addition to communication among team members, it also includes communication with users (interviews and user requirements analysis). Accordingly, it is useful to simulate different stages of software development (Offutt, 2013). Besides the ability to creatively solve software design problems, software engineers should be creative in the design and implementation of interviews and system analysis (Nguyen & Shanks, 2009), i.e., requirements gathering (interview and questionnaire) and data flow diagrams of different levels (Rob, 2013). The interview with the user (either real or emulated) can be one of the activities that will connect students with real-world projects within a real teamwork environment (Fertalj et al., 2013). An assignment for students in the process of teaching interviewing skills can include practice interview sessions in the form of a role-play (Taylor, 1999). Peer reviews can be useful for assessing created software artefacts, including software requirements and design (Lavy & Yadin, 2010; Søndergaard & Mulder, 2012). Within the designed learning activities students can work in a team to train social skills and learn about project management as well as the importance of design and coordination efforts (Broman et al., 2012). Students should also have the opportunity to experience the client side of system development through collaboration with real companies (Surendran & Young, 2000) or guest lectures (Wohlin & Regnell, 1999).

When formative assessment activities are performed online, it is necessary to choose the right tools (Gikandi et al., 2011; Pachler et al., 2010; Salahat & Wade, 2014). In the process modeling domain, students can use commercial desktop or tools available online (Redondo et al., 2014) that enable communication and collaboration. There is a variety of online digital tools can be used in e-tivities like conducting interviews for the purpose of requirements elicitation (De Freitas & Borges, 2003) process model sketch elaboration (Baloian & Zurita, 2011) or for collaborative modeling (Recker et al., 2013; Holenko Dlab et al., 2017).

Timely feedback of formative assessment activities that happens as soon as possible is very important for students' motivation (Weurlander et al., 2012). Comments should provide corrective advice and should be set in the context of assessment criteria. Although more feedback should be delivered to lower than to higher achievers (Glover & Brown, 2006), feedback should not be focused only on the negative elements of the assignments. Besides positive changes of cognitive state, feedback should encourage positive changes of affective or motivational states as well (Nicol & Macfarlane-Dick, 2006). Students will find feedback unhelpful if it is too general or vague and if it does not contain suggestions for improvement (Weaver, 2006). It is desirable to also provide opportunities for getting feedback from peers, which can also reduce the teacher's workload. This is possible through activities such as peer-assessment and peer-review where students give each other scores and/or feedback on assignment before the teacher will evaluate it (Lavy & Yadin, 2010; Pachler et al., 2010). Collaborative learning activities where students work together towards a common goal also represent the opportunity to obtain feedback from peers (Hassan, 2014; Willey & Gardner, 2012).

Internal feedback, which is also needed (Nicol & Macfarlane-Dick, 2006; Pachler et al., 2010), can be reached through self-assessment (reflection) where students are making judgements about how their work relates to the assessment criteria.

METHODOLOGY

RESEARCH DESIGN AND PROCEDURE

In order to achieve the main goal of this research, which is to evaluate the effectiveness of proposed approach, one e-course was selected. It is the course "Process Modeling" which is part of the Computer Science major. The course emphasizes the project approach and practical tasks required to work in practice.

To try to encourage a greater level of acquired theoretical content and enhance the acquisition of subject-specific skills needed for practical tasks, new activities are designed. All additional activities were carefully designed and introduced to the flow of course activities, taking into account the intended learning outcomes and specificities of the course content. New activities are implemented in the form of formative knowledge assessment in order to enable students to obtain feedback. Activities are designed to involve collaborative learning so apart from teacher's feedback, students have the opportunity to get feedback from their peers. For the realization of some activities online digital tools (Web 2.0 tools) were used.

The effectiveness of the proposed approach was evaluated using a comparative study. During the study, the same two teachers managed the course for both, the control and the experimental groups. The same lecture content was used as well as the task of the practical assignment at the end of the course. The exams were prepared according to the same model. The difference was in six activities that were included in the course learning design for the experimental group. Results of theory exams and practical assignment for students from the control and experimental groups were statistically analyzed. These results enabled the comparison of students' achievements during the e-course delivered with and without activities for formative assessment. Accordingly, the main hypothesis of the research was: *Students who participated in formative assessment activities achieve significantly better results during e-course.*

In addition, in order to examine students' attitudes towards applied approach, students from the experimental group were asked to reply to an anonymous questionnaire.

PARTICIPANTS

Study participants were undergraduate students of Computer Science major. All students who took the course "Process Modeling" after it was improved using the proposed approach were in the experimental group (N = 82, 46.3% females) while students who took the course during previous academic year were in the control group (N = 66, 48.5% females). In order to determine possible difference between the observed groups of students regarding knowledge and skills needed to master the content of the course, the final scores that students achieved in two courses were analyzed. The first is a 1st year course "Informatics Fundamentals 2", in which students acquire basic knowledge in the field of information technology, including the basics of software development, the role that members of the development team have in a development project, the role of users during software development and its application, and the importance of software that provides support to the business process of the organization. The second course used for the comparison of groups was "Information Systems" during which students learn about different development methodologies, get the general view of information systems and the role of the software that supports it.

Results of the D'Agostino-Pearson test for normal distribution for the control and experimental groups showed that parametric test for comparison of independent samples should be used in case of "Informatics Fundamentals 2" while in the case of "Information Systems" non-parametric test should be used. The results of the Welch test showed that there is no difference between the observed groups in the case of "Informatics Fundamentals 2" ($p=.67$). The Welch test was chosen due to a difference in variance. Correspondingly, the results of Mann-Whitney U test showed that there is no statistically important difference in the case of "Information Systems" either ($p=.16$).

DATA COLLECTION AND ANALYSIS

To test the hypothesis, points that students earned for theory exams and practical assignment were compared. During the descriptive statistical analysis, the low values of the coefficient of quartile deviation were determined for all grading components in case of both groups. This indicated that the median is representative of the central tendency. To decide what test will be used to compare two independent sets of data (results of the control and experimental group), the D'Agostino-Pearson test of normality was first performed. If normality was concluded for both groups, Student's t-test for parametric samples was chosen based on the result of the F test of equality of variances. If normality was not concluded for at least one of the groups, Mann-Whitney U test for nonparametric samples was chosen (Fraenkel et al., 2012).

In addition, an anonymous online questionnaire was conducted with the students from the experimental group in the Moodle LMS to assess their attitudes towards the implemented approach. The questionnaire was available to students at the end of the semester. It consisted of 21 statements with 5-point Likert scale (1=completely disagree, 5=completely agree). Statements were divided in three groups in order to examine students' satisfaction with the realization of e-course, students' attitudes about the usefulness of particular activities for formative assessment, and usefulness of Web 2.0 tools for their realization. Their answers were collected and statistically analyzed. To measure the reliability, Cronbach's α (Fraenkel et al., 2012) was calculated for each group of statements. At the end of the questionnaire, there were a couple of open-ended questions. Students were asked what they would change in this e-course as well as to write their comments regarding course activities.

IMPLEMENTATION OF THE APPROACH TO THE E-COURSE "PROCESS MODELING"

COURSE CONTENT AND OBJECTIVES

The course "Process Modeling" is taught at the authors' institution as a blended learning course (López-Pérez et al., 2011) that combines face-to-face lectures and activities with online teaching with the help of the LMS Moodle. The course carries a total of 5 ECTS credits, and during the course, students learn how to conduct analysis of business processes that take place in an observed business system and elicit requirements. Also, based on the results of the analysis, they learn to create a system process model using the Structured System Analysis method.

The material of the course is divided into three main units (themes): Business system processes, Business systems analysis and Process model development. In the first unit, during the lectures, students are introduced to business system processes, their analysis and process model design. Upon completion of this unit, students will be able to define, connect and understand the basic concepts and "read" completed process models with understanding. Students will understand complex systems and know how to decompose them into simpler parts. In the second unit, lectures and materials are used to prepare the students for self-interviewing and process modeling. At the end of this unit, students will be able to apply structured system analysis, create data flow diagrams, analyze and decompose business processes. They will be able to create and present the structure of business processes using different techniques, for example Warnier-Orr diagrams. Also, students will be able to independently interview a user, analyze business system processes and perform their decomposition. In the third unit, lectures cover abstract approaches to different levels of process models, common mistakes with process modeling, and recommendations for process modeling. Students develop a "design mode" of thinking. Upon its completion, students will be able to critically analyze, assess and evaluate their own and others' results of decomposition and the obtained models.

COURSE ACTIVITIES FOR SUMMATIVE ASSESSMENT

The main activities used to examine the acquisition of learning outcomes are described below.

Theory exams

In the Moodle system students solve three online tests which include different types of questions (multiple choice, connection, true/false, short answer and essay). The first theory exam (T1) checks factual and conceptual knowledge, the second exam (T2), using descriptive questions, checks for understanding and application of the wider context, and in the third theory exam (T3) the student is (among other things) expected to think critically about the given process models and their semantic quality.

Practical assignment

Practical assignment (PA) includes activities of collecting documents used in a selected business system, developing process hierarchy, process decomposition, drawing data flow diagrams for all analyzed levels of the observed system. Students independently perform the task, following the deadline defined at the beginning of the semester. For creating this practical task, all conceptual knowledge acquired earlier in the course is deployed. This assignment is performed using Creately, Microsoft Visio or similar tool. The developed process model is evaluated by the teacher depending on the accuracy, completeness and complexity.

Peer review

This activity is carried out in the classroom, just before handing in seminar papers. Every student observes the model (seminar paper) which is made by another student and by applying the rules on the limitations during reading the finished model, he/she indicates errors and explains them. The aim of this activity is to encourage a deep understanding of content using critical approach and evaluation of the accuracy of the colleague's model. At this point, this activity is not included in the formative assessment because students do not have the opportunity to correct errors based on feedback from colleagues, but this is planned to be changed in the future.

Implementation of Formative Assessment Activities to Advance the Course

The proposed model emphasizes providing formative assessment. Therefore, when planning additional activities for the selected course, their order and the learning outcomes of an individual unit were taken into account. In the first stage, students learn the basic concepts of the theory and work on conceptual understanding of the area. In the second stage, they apply conceptual knowledge to solving simple problems of design, and in the third stage they create their own model and critically observe other models. These learning stages are also applicable to engineering education in general.

Activities performed by the experimental group in relation to those performed by the control group are shown in Figure 1 and described in more detail below. In addition, both groups attended lectures. Apart from the purpose of formative assessment, new activities were also used as part of the summative assessment, as shown in Table 1.

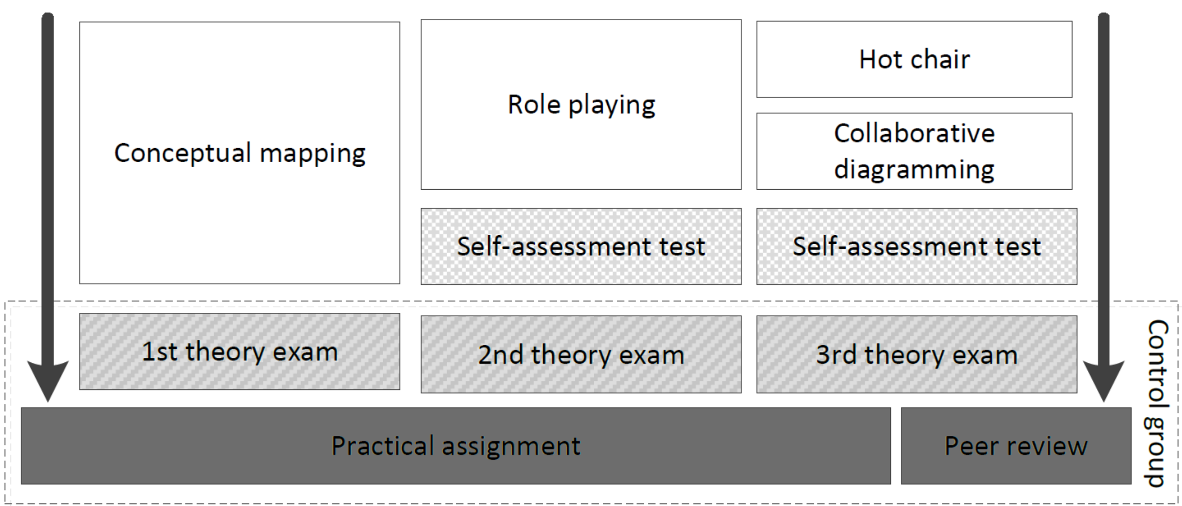

Figure 1. Course activities performed by the control and experimental groups

Self-assessment tests

Using online self-assessment tests that students can take before theory exams in the Moodle system, they can test their knowledge of units included in second and third theory exams. The questions are mostly of the objective type and students receive feedback results immediately after taking the test (percentage of accuracy, accurate answers to the questions and additional explanations). Questions of the subjective type are afterwards evaluated by the teacher so, in the case of incorrect or incomplete answers, the students receive written feedback in which it is briefly explained what the student has omitted or it indicates misconceptions.

In order to increase understanding of the material and enable the achievement of higher levels of learning outcomes, e-tivities through which students have the opportunity to develop practical skills, are also designed. They are performed online and assume collaborative work. Before each e-tivity, students group themselves into teams and receive instructions with evaluating criteria.

Conceptual mapping

Teams of up to four students should create an online conceptual map with key concepts of the assigned topic. This activity is designed to help students to better master the conceptual knowledge tested in the first theory exam. During the development of the map, the student links concepts through interpretation of the teaching content and thereby receives feedback from colleagues in the group. Students use the MindMeister tool that enables real-time collaboration. The teacher checks and evaluates completeness, correctness of connections and visual appearance of maps and gives feedback on the map for the entire group. He/she also estimates the contribution of each member of the group to the final solution based on the history of map creation and provides students with individual feedback regarding his/her activity level.

Role playing

Before taking the second theory exam, students undergo the role play activity, during which they work in pairs and develop collaborative and social skills. The student is put in a real business system situation, with the aim of experiencing the user's point of view. By applying the conceptual knowledge of the second unit and knowledge of the business system that they have chosen at the beginning of the semester (for the purposes of practical assignment), students simulate the interview process. One student plays the role of the analyst and the other one is the user. The analyst's task is to draw functional decomposition diagrams and context diagrams for the business system chosen by the student who plays the role of the user. Students then change roles. The task also assumes that the student playing the user gives a critical overview of finished diagrams created by the student in the role of analysts, which further encourages the acquisition of concepts and linking conceptual content with practical needs. The student has the opportunity to self-evaluate his/her knowledge and skills in the implementation of the interview and get feedback from colleagues. The support for this task is provided by a Web 2.0 tool Creately which enables real time communication and collaboration. The teacher assesses the syntactic quality of the model (the correct use of modeling concepts) and semantic quality of the model (the completeness and accuracy of the model representation of the actual business system) as well as the level of system decomposition. Insufficient decomposition of the system processes and incompleteness of input and output data flows are an indication that the student needs to work on elicitation methods prior to the analysis of the selected system and the interview with the user. Therefore, such errors are indicated in the feedback.

Collaborative diagramming

Before the third theory exam, students have the opportunity to create a model in a team, whereby they learn teamwork and develop social and collaborative skills. Students form teams of five members. Each team receives a textual description of the processes at the lowest decomposition level (elementary processes), which is the result of a system analysis implemented by real analysts. Based on the textual description of elementary processes, students collaborate in the online environment and draw a process model using the Creately tool. During the development of the model students need to apply what they have learned during the course and they have the opportunity to realize their mistakes and learn from colleagues. The teacher checks the process model for each team by comparing the completeness of the created process model with textual description. and evaluates the contribution of each member (relying on the review of drafts that preceded the final result). The teacher evaluates how well students understand the processes of the system, estimates the completeness of all levels of process model and checks balance of data flows. Any problems (errors) reveal a lack of understanding of the material, so feedback indicates what they should pay more attention to during the development of the process model of the system chosen for the practical assignment.

Hot chair

In addition to the above e-tivities, face-to-face activity *hot chair* is also included in the course workflow.

Given the fact that for future software engineers, as well as for each engineering discipline, the relationship with the real application of knowledge in practice needs to be created, an experienced analyst's visit is organized during classroom lessons. Students learn about the practical experience of analysts on real projects, and actively participate in the discussion. Analyst presents his/her job, so students get the opportunity to learn the answers to questions that interest them. In communication with the analyst, students use knowledge gained during the course. The conversation serves to identify the basic concepts, but also as a motivation for further acquisition of knowledge in the field of modeling processes. This activity in the classroom is planned as an alternative to students visiting software companies, because of the large number of students enrolling the course.

GRADING

Although the primary aim of implementation of new activities described above was formative, to ensure that students receive feedback, they were included as a part of summative assessment as well (20% of the course points). Grading points for all course activities included in the summative assessment for the experimental group are shown in Table 1. Some activities had a threshold on points so number of points that students had to achieve for certain activity is also shown (in the brackets). After totaling all points earned, the final grade was calculated for all students with at least 40 points according to the following scale: A - excellent (5), 70-79.9; B - very good (4), 60-69.9; C - good (3), 50-59.9; D - satisfactory (2), 40-40.9; E - satisfactory (2). Others fail and must retake the course in the next academic year.

Course points awarded from all components were collected and analyzed. Although two teachers performed the lectures, all activities of the control and experimental groups were evaluated by one teacher. Students' participation in activities was assessed according to predefined criteria, depending on the accuracy and completeness, i.e. the quality and quantity of created content. Assigned points were delivered to the students using the Moodle LMS grading subsystem. In addition, students received teacher's feedback. Online tests performed in Moodle LMS (self-assessment tests and theory exams) were graded automatically, except the subjective type questions from theory exams that were manually graded by the teacher.

Table 1. Course activities

	ACTIVITY	TYPE	TOOL	ASSESSMENT	MAX. POINTS (THRESHOLD)
Part 1	Conceptual mapping	Online Collaborative (group-based: 4 members)	MindMeister	0-5 points, depending of the quality/quantity of contribution	5 (-)
	T1 - 1st theory exam	Online Individual	Moodle LMS	0-20 points, depending on correctness	20 (8)
Part 2	Role playing	Online Collaborative (group-based: 2 members)	Creately	0-4 points according to the specified criteria	4 (-)
	Self-assessment test	Online Individual	Moodle LMS	0 - 1 point, depending on correctness	1 (-)
	T2 - 2nd theory exam	Online Individual	Moodle LMS	0-20 points, depending on correctness	20 (8)

	ACTIVITY	TYPE	TOOL	ASSESSMENT	MAX. POINTS (THRESHOLD)
Part 3	Collaborative diagramming	Online Collaborative (group-based: 5members)	Creately	0-5 points according to the specified criteria	5 (-)
	Peer review	Face-to-face Collaborative (group-based: 2 members)	-	0-4 points according to the specified criteria	4 (-)
	Self-assessment test	Online Individual	Moodle LMS	0 - 1 point, depending on correctness	1 (-)
	T3 - 3rd theory exam	Online Individual	Moodle LMS	0-15 points, depending on correctness	15 (6)
	PA - Practical assignment	Individual	Creately, Microsoft Visio or similar	0-25 points according to the specified criteria	25 (10)
				Total:	100

The distribution of points for activities in the control group differs slightly from those in the experimental group. The *peer review* task in the control group had a maximum score of 10 points, while in the experimental group it had 4 points. In addition, students from the control group created tasks during lessons with the help from the lecturer and were evaluated with a maximum of 10 points for their activity in performing the tasks.

RESULTS

COURSE RESULTS

Descriptive statistical analysis of students' points per main grading components is shown in Table 2. The table shows number of participants (N), minimum, maximum, arithmetic mean, and standard deviation, median, coefficient of quartile deviation and results of D'Agostino-Pearson test for normal distribution for the control and experimental groups.

Table 2. Descriptive statistical analysis of students' points

GRADING COMPONENTS		T1	T2	T3	PA	FINAL RESULT
Control group (N=66)	Minimum	0	0	0	0	0
	Maximum	19.05	20	14.44	25	96.71
	Arithmetic Mean	10.55	11.94	6.72	13.70	53.77
	Standard deviation	4.04	5.76	3.83	8,56	24.42
	Median	10.67	13.63	7.45	12.50	58.15
	Coefficient of quartile deviation	0.02	0.05	0.02	0.06	0.09
	D'Agostino-Pearson test	p=.2078	p=.0492	p=.2547	p<.0001	p=.1125

GRADING COMPONENTS		T1	T2	T3	PA	FINAL RESULT
Experimental group (N=82)	Minimum	3.97	6.48	0	0	25.75
	Maximum	18.43	19.6	13.61	25	90.42
	Arithmetic Mean	12.19	14.15	8.87	17.25	64.08
	Standard deviation	2.79	3.37	3.33	6.45	13.62
	Median	12.15	15.15	9.38	19.25	64.05
	Coefficient of quartile deviation	.02	.03	.02	.05	.14
	D'Agostino-Pearson test	p=.7739	p=.0562	p=.0004	p=.0271	p=.2601

The results of comparison of measuring central tendency for all grading components are shown in Table 3. A significant difference between medians of results for the main grading components was observed in favor of experimental group and, therefore, the hypothesis was accepted. It was concluded that students who participated in activities used for formative assessment achieved significantly better results on theory exams and practical assignments. In addition, a significant difference between the medians of final results was observed in favor of the experimental group (p=.0014).

Table 3. Comparison of medians for main grading components and final results

GRADING COMPONENTS	T1	T2	T3	PA	FINAL RESULT
Control group	10.67	13.63	7.45	12.50	58.15
Experimental group	12.15	15.15	9.38	19.35	64.05
p	.0042*	.0178**	.0001**	.0198**	.0014*

**Student's t-test*
*** Mann-Whitney U test*

Questionnaire Results

The results of the distributed anonymous questionnaire are presented in Table 4. Of the 82 participants in the experimental group, 72 completed the questionnaire (87.8%). For each group of statements, summated results are reported together with the reliability coefficient Cronbach's α. In addition, single item analysis for used statements was also performed to gain a better insight into students' attitudes.

In the open-ended questions, students emphasized continuous work through a series of activities as an advantage, but some of them declared that they prefer individual activities.

Table 4. Questionnaire statements with the results (N=72, α=.91)

STATEMENT	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	MEAN	SD
1. Satisfaction with the e-course (α=0,84)	**.52**	**2.60**	**14.06**	**47.92**	**34.90**	**4.14**	**.79**
1.1. I'm satisfied with course learning model which includes activities that precede theory exams.	1.39	2.78	8.33	55.56	31.94	4.14	.79
1.2. Applied learning model is effective for learning the course subject matter.	1.39	.00	8.33	56.94	33.33	4.21	.71
1.3. Learning materials and activities are well organized.	.00	4.17	19.44	43.06	33.33	4.06	.84
1.4. Instructions for activities are clearly written.	.00	5.56	9.72	44.44	40.28	4.19	.83
1.5. I am satisfied with the way the teacher managed activities and communicated with students during the course.	.00	.00	5.56	40.28	54.17	4.49	.60
1.6. Activities preceding the theory exams had positive influence on my knowledge level and my exam results.	.00	.00	19.44	50.00	30.56	4.11	.70
1.7. Continuous engagement that was encouraged during the course had positive influence on my final course points.	1.39	1.39	19.44	47.22	30.56	4.04	.83
1.8. Various activities that were planned during the course had positive influence on my motivation for learning.	.00	6.94	22.22	45.83	25.00	3.89	.86
2. Effectiveness of course activities (α=0.80)	**2.38**	**4.37**	**15.67**	**42.26**	**35.32**	**4.04**	**.95**
2.1. I find available self-assessment tests effective for learning.	2.78	6.94	11.11	38.89	40.28	4.07	1.03
2.2. I find "Conceptual mapping" activity effective for learning.	4.17	5.56	22.22	43.06	25.00	3.79	1.02
2.3. I find "Role playing" activity effective for learning.	1.39	4.17	22.22	45.83	26.39	3.92	.88
2.4. I find "Hot chair" activity effective for learning.	2.78	4.17	11.11	31.94	50.00	4.22	1.00
2.5. I find "Collaborative diagramming" activity effective for learning.	.00	2.78	16.67	47.22	33.33	4.11	.78
2.6. I find "Peer review" activity effective for learning.	4.17	5.56	15.28	48.61	26.39	3.88	1.01
2.7. I find "Practical assignment" activity effective for learning.	1.39	1.39	11.11	40.28	45.83	4.28	.83

STATEMENT	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	MEAN	SD
3. Usefulness of Web 2.0 tools (α=0.87)	**7.20**	**15.60**	**34.00**	**.00**	**43.20**	**3.75**	**1.06**
3.1. Web 2.0 tools useful for realization of collaborative learning activities.	4.17	5.56	23.61	50.00	16.67	3.69	.96
3.2. Facilitating collaboration with colleagues is an advantage of Web 2.0 tools for e-learning.	4.17	2.78	22.22	43.06	27.78	3.88	.99
3.3. Possibility to create, publish and share content is an advantage of Web 2.0 tools for e-learning.	2.78	6.94	18.06	44.44	27.78	3.88	.99
3.4. Access using Web browser (without installation) is an advantage of Web 2.0 tools for e-learning.	.00	1.39	8.33	47.22	43.06	4.32	.69
3.5. I find the MindMeister tool useful and I would like to use it again.	5.56	19.44	22.22	33.33	19.44	3.42	1.17
3.6. I find the Creately tool useful and I would like to use it again.	8.33	18.06	23.61	34.72	15.28	3.31	1.18

DISCUSSION

The research results showed that students who participated in activities for formative assessment achieved significantly better results on theory exams and practical assignment. By participating in the development of conceptual map and solving tests for self-assessment, students from the experimental group had the opportunity to establish important concepts of each unit, which represents the first stage of learning. According to the results, knowledge of the conceptual content was at a higher level, which is evident from a comparison of the results of students in the theory exams. Participation in this type of activity is very important for students to acquire knowledge for activities that will follow but also because of their future expert approach and understanding of problems (Watson et al., 2016). In general, engineers need deep conceptual understanding in order to be able to carry out critical analysis of new problems and solutions (Montfort et al., 2009). The development of conceptual knowledge is an iterative process (Leppävirta et al., 2011), so reaching deeper conceptual understanding is also expected through performance of activities that follow later in the course delivery.

Appropriate activities for the second and third stage of learning are designed, which, along with a deeper understanding of the material, include the acquisition of specific practical skills (in this case the interview) and the development of design art. During the evaluation of students after the completion of the second stage of learning, students are required to analyze simpler problem situations with their own interpretation, to synthesize knowledge and to propose a solution, while at the conclusion of the third stage of learning, students are expected to identify, critically evaluate and describe the potential problems of finished models, as well as to understand the entire process of creating a process model. The acquisition of practical skills of interviewing and design are tested through an assignment at the end of the semester. Students are prepared for this task by participating in *role playing* activities and *collaborative diagramming*. In order to achieve the role of formative knowledge assessment, after completing the activities, the teacher pointed out the failures and mistakes to the students, in order to avoid them during the development of a practical task. The results show that the solutions of the practical task are significantly better in quality (which is evident from a comparison of indicators of central tendency of their results - points). This is a very important finding because through the specified task students show understanding of the overall course material and apply acquired skills to concrete problems from practice.

Questionnaire results indicate that students are satisfied with the proposed approach. They find it more effective for learning and state that it has a positive influence on their motivation for learning. Also, they expressed their satisfaction with the way the teacher organized and led activities. They recognized the advantage of continuous work and participation in the activities of formative assessment. Moreover, students find all formative assessment activities included in the course useful. The *practical assignment* was considered the most effective activity for learning. This response was to be expected as the most common because, by solving practical tasks, students get the closest to what is done in practice. The use of formative activities as preparation for this task ensures that students are better prepared for it, achieve better results and acquire more knowledge.

Some students stated they would prefer individual activities instead of teamwork. To achieve successful careers, students should develop competencies for communication and collaboration as well and students need to be constantly reminded of this. The opportunity for this during the course was a discussion with experts in the framework of the activity *Hot chair*. Most students have recognized the advantage of these activities in which they can hear about the experiences of work in practice and what employers expect from (future) software engineers. Invited experts will be asked to present their experiences in teams for software development and how team members work together and contribute to the final product.

Furthermore, students have recognized the benefits of using digital tools, especially because they can be accessed via a Web browser (no installation required). In open-ended questions students have praised MindMeister tool that was used to create the conceptual maps. They stated that they use this tool in other courses as well. The tool has proven to be good according to teachers as well. A great advantage is also the possibility of insight into the way the maps are created and into the list of changes on the map that are created by the individual student. For the purposes of diagramming, instead of using a commercial program (e.g., Microsoft Visio), in this course, a free online tool Creately was used for the creation of models. Students are partially satisfied with this tool because they are not aware of the fact that collaboration requires a certain new organizational effort. Teachers noted that Creately does not provide a systematic review of the work of each team member, like MindMeister does, but the evaluation of a student's contribution must be done by viewing different versions of the model instead. This type of work involves constant monitoring of students in order to provide adequate feedback, and to evaluate the contribution of individual collaborators to the final result. Therefore, the functionalities that enable undisturbed collaborative work and provide a better insight into the activities of individual collaborator for the teacher are important when choosing tools.

Besides Creately, there are other online tools for diagramming so teachers are free to choose the one that meets the course's needs.

The main limitations of the presented study include a small number of participants and the fact that the experiment was conducted within one course. Therefore, further research is needed within similar courses with a larger number of students to confirm the obtained results.

CONCLUSIONS AND FUTURE WORK

The paper presented an approach that introduced activities for formative assessment of students' knowledge into the course. The aim of applying the approach is to enhance the implementation of planned learning outcomes related to the acquisition of conceptual knowledge, but also skills needed for work in practice, and is therefore particularly suitable for implementation in the education of future engineers and experts in the field of computer science and information-communication technology. Activities for formative assessment precede the main components of assessment. They should be consistent with the learning outcomes and designed to provide students with an insight into the current level of acquired knowledge and skills through the feedback they receive from teachers or peers or through self-assessment. In addition, important characteristics of activities covered by the approach are also encouraging collaborative learning and combining different technologies for the realization of intended activities. Since activities presume collaborative interaction between students, they also help to develop other skills important for future software engineers.

The proposed approach was evaluated by comparing the results on the course "Process Modeling" which were achieved by students from the control and experimental group. Students from the control group followed the e-course during which face-to-face teaching was aided by the use of LMS, and the acquisition of teaching content was tested through four activities for assessment: three theory exams and one practical assignment. In addition to these activities, only the *Peer review* activity was conducted after submission of seminar papers during the course.

In the case of course delivery for the experimental group, the proposed model was used and six additional activities for formative assessment were introduced. The results confirmed that the approach can be used for increasing students' academic achievements. Students from the experimental group achieved significantly better final results in the course. They achieved significantly better results in regard to major components of evaluation that assesses the acquired conceptual but also practical knowledge. Also, according to the results, students are satisfied with this approach to teaching and they find the implemented activities to be effective for learning.

Along with the increasing of students' success, the continued application of this model is certainly motivated by the teachers' observation that the usage of activities that enable formative assessment and collaborative experiences positively affected students' motivation for learning. According to the experience of teachers, students are very impressed with the conversation with an expert (activity *Hot chair*). Since this approach was developed and implemented before COVID-19 pandemic, which imposed the need for teaching in an online environment, it assumes the combination of face-to-face and online activities. In our future work we will adapt the face-to-face activities (*Peer review*, *Hot chair*) for performance in an online environment.

Future work will also include further evaluation of the approach in other e-courses from the field of software engineering, computer science and information communication technology. Also, the possibilities for personalization of activities for formative assessment will be considered, in accordance with the characteristics of students, such as the level of knowledge, level of activity, the level of communication.

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