Co-funded by the
Erasmus+ Programme
of the European Union

METHODOLOGY TO ASSESS HIGH SCHOOL STUDENTS LEARNING TO EVALUATE INFORMATION SYSTEM USABILITY

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Abstract

The usability of information systems determines their success in the market. Therefore, it is important to assess the usability of a system during its development. In higher education, we have to assess how students have learned to evaluate the usability of information systems. The paper is aimed to present a methodology for assessing the learning of students in higher education.

Students were involved in the development of genuine information systems for the market. This approach improves their learning quality and motivation to seek for new knowledge and greatly enhances study efficiency. This methodology is based on applying combined methods: expert-based methods (namely, Heuristic Evaluation) and participant methods (namely, Event diaries).

From 2020 till now, evaluation of student achievements was done via including them into genuine projects carried out at the Vilnius University of Applied Sciences. Students had to evaluate the usability of the information system being developed.

Between October and December 2020, first- and second-year students from three study programs, making 10 groups, participated in usability testing of the CVSite tool by applying participant methods. In total, 85 students were conducting usability testing. During testing with participant methods, the "Event Diary" was applied. After the test, an "Impressions after testing" survey was carried out. Students had to record system defects in the event log, constructed of decomposed tasks. The final report comprised 456 properly described events. 85 respondents participated in the post-test impressions survey.

In April 2021, the second testing cycle of the CVSite tool took place by 3 student groups following the same approach. In this test students additionally had taken a Human-Computer Interaction Design course and participated in the testing as usability experts. The evaluation of the tool constituted 50% of the evaluation of the course exam.

In the combined testing approach, the same “Event diary” was applied during testing, where students who recorded a defect indicated compliance with the heuristics formulated by the researchers during the first testing cycle. A total of 941 events were recorded, but only a fraction of them were properly described. 39 events were incorrectly recorded, representing 4.14% of the total number of events. In addition, some positive aspects of the tool under test were recorded (252). However, the majority of the events, 650 (69.1%), were correctly recorded and described. Noted defects in the events could be analyzed and the heuristics (type of defect) could be determined. The list of defect types was expanded within the item “Other”, where the students chose the Nelson heuristic to describe the defect.

In April 2022, the combined testing approach was reapplied in a usability evaluation of the Knowledge Alliance Business Idea Assessment Tool. 33 first-year students participated in the following test, recording 583 events. The article analyzes and presents the results of student evaluation. This combination of expert evaluation methods and participants' methods allowed assessment of how involving students in genuine projects can improve the quality of learning and motivate students.

Keywords: Learning assessment, usability, usability evaluation methods, methodology.

1 INTRODUCTION

Nowadays, use of software has become prevalent in every part of community life. Software development has changed dramatically over the past decade, currently being exploited for a greater variety of fields and purposes. The usability of information systems determines their success in the market. Therefore, it is important to assess the usability of a system during its development.

User interface (UI) is an interactive software component. For the reasons above, discipline of software engineering plays an important role in teaching students about the different user interfaces in use among

a variety of industry fields. They must know how to design and evaluate them, learn from the existing technologies and previous case studies of (good practices/ developed projects).

Software engineering courses focus mostly on the programming and architecture of the application logic while giving limited attention to the UI design and evaluation. Frequently, software developers rarely get any further training in designing and evaluation of UI after the courses are finished, thus it is detrimental to get the main principles of these during the studies.

Evaluation of the progress during the studies is a part of a teaching process, which is often neglected due to being stressful for the students. On the other hand, getting students involved in the actual projects under development greatly increases their motivation and willingness to get deeper into the field of interest. Current article presents data from two years monitoring and evaluation of student examination in Human Interface Development course results. Evaluation was done using the usability assessment tools currently in development, later described in the article. The aim of the study is to develop a methodology for assessing the learning of students in higher education. Alongside trying to increase students' motivation, by getting them involved in the development of genuine information systems for the market.

The rest of the paper is organised as follows: research methodology is presented in Section 2, systematic review results and research results are provided in Section 3, and Section 4 concludes the paper.

2 METHODOLOGY

According to the aim of an article, the methodology of the systematic analysis of the literature and research is presented below.

2.1 Systematic Review

In order to specifically find research on usability and acceptance, an exhaustive search conducting a systematic review was performed. This systematic review was conducted following the process proposed by Kitchenham [1] and Biolchini [2].

The methodological steps, the strategies to retrieve the evidence, and the focus of the question are explicitly defined by Biolchini [2]. According to Kitchenham [1], this process presents three main phases: (1) Phase 1 – Planning: In this phase, the research objectives and the review protocol are defined. The protocol constitutes a predetermined plan that describes the research questions and how the systematic review will be conducted; (2) Phase 2 – Conduction: During this phase, the primary studies are identified, selected and evaluated according to the inclusion and exclusion criteria established previously. For each selected study, data are extracted and synthesized; and (3) Phase 3 – Reporting: In this phase, a final report is formatted and presented.

Search history in Clarivate Analytics Web of Science database is presented in Figure 1:

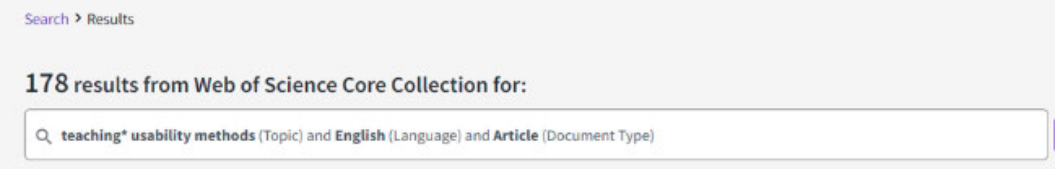

Figure 1. Search history in Clarivate Analytics Web of Science

The authors have performed all systematic review phases strictly following this previously described methodology. Review question is clearly formulated, and only articles of the last 5 years are taken for the analysis.

According to the requirement of the systematic review process, during Phase 1, the research question was raised as “teaching usability methods”. Our aim was to explore methodologies to assess high school students learning to evaluate information system usability. Timespan was chosen “the last 5 years”, document types – Articles, and language – English.

During Phase 2, 178 primary articles were identified in the Web of Science database, selected and evaluated according to the research question. After screening, 20 articles were selected for detailed examination. Search was conducted on December 7, 2021.

2.2 Research

In 2019-2021 Vilniau kolegija/ Higher Education Institution had a project “Automated CV development platform based on artificial intelligence module”, no. J05-LVPA-K-04-0056. First stage of the project was in 2019 from October till December. It was composed of 10 groups of first and second year students (Information Systems and Software Engineering programs). They conducted the first usability test of the CVsite tool. Yet, not all students had the background of Human-Computer Interaction Design course, thus for analysis participant method (namely, Event diaries) was selected.

In total, 85 students were conducting usability testing of CVsite tool. Students had to record each system defect encountered in the event log, constructed of a decomposed task. Upon finishing they had to take an "Impressions after testing" survey. In total 543 events were registered, yet 18.02 % (87 events) were not properly annotated. Well annotated 456 events (83.98%) were taken for further analysis according to the type of defect.

From the event log and its descriptions authors have constructed a heuristics (Section 3.2.1). While performing usability testing, problems of student motivation have been noticed. There are a number of projects at the Vilniau kolegija/ Higher Education Institution that have the aim of developing a tool for the market. Therefore, in order to increase student motivation and provide real testing experience, the project was carried out as a part of a study for Human-Computer Interaction (HCI) Design course.

The course was marked with the following task-percentage distribution: 20% case study, 20% test, 40% practical work, 20 % exam. Exam is given in a form of task to evaluate the usability of a simulated situation using appropriate Expert evaluation methods and Participant-based methods.

In April 2021, the second testing round of CVsite tool took place, yet with a smaller number of people, 47 students from HCI course, making 3 student groups. Yet, in this round students could register not just the defects, but also the successfully realized aspect using combined testing approach expert-based methods and participant methods. The same “Event diary” was used to describe defects using a participant based approach. As usability experts the students had to assign each described event (defect or positive aspect) to either heuristics formulated in the first testing round or to Nelson’s heuristics. Students have been graded according to their participation: having registered not less than 5 defects or 10 positive aspects students received 50%, respectively, if registered 10 defects or 20 positive aspects - 100%.

Second round of testing was designed to be a part of HCI design course examination making 50% of the final exam mark. Students of the course were free to choose either to have a standard exam composed of 3 case studies for evaluation, or have a project integrated exam that had additionally just one case study evaluation for another 50 %.

Similarly, in the second round a total of 941 events were recorded, yet only a fraction of them was properly described. Events had the following distribution: 39 events were incorrectly recorded, making 4.14%; 252 positive aspects taking 26.78%, remaining majority 650 events (69.1%) noting correctly annotated defects. Positive aspects and well annotated defects were further analysed.

A third testing round took place in April 2022. A combined testing approach of the second round was reapplied in a usability evaluation of a different tool: Knowledge Alliance Business Idea Assessment Tool. 33 first-year students participated in the following test, recording 583 events.

Structure of event log:

1 Time log: a) group, name/surname b) Decomposed task titles (chosen from a list).

2 Defect description (short description) a) link to defect directory b) How problem was encountered? What step was taken or what kind of input data was given before the problem occurred? If unknown notification, what is it? If there is an unknown button, what? Next step unknown? Give a comment for a defect; c) Choose heuristic (Formulated by researchers + 11.Other + 12.No defect) d) if “Other” or “No defect” Nelson heuristic is given.

3 What auxiliary tools were used for help?

4 Did acquired information help to solve the problem?

3 RESULTS

3.1 Results of Systematic Review

A comparative analysis of the articles is presented in Table 1.

Table 1. A comparative analysis of the articles

Source	Short description	Methods
[4]	Teaching method applied in a usability research course in Academy of Fine Arts.	1, 2, 3
[5]	Students' and instructors' experiences with usability testing in technical communication service courses.	2
[6]	Google Cloud, Microsoft Azure (CSP) and its own cloud network usability evaluation to measure its fit to learning and the use of a product for teaching in cybersecurity courses.	1, 4
[7]	Usability evaluation for a desktop-based Translation Memory tool from the end user's point of view to measure its appropriateness with respect to learning and the use of Computer-Assisted Translation tools for teaching in translation classes.	5
[8]	Virtual Programming Lab Module for Moodle usability evaluation for learning purposes and the use of a product for teaching in computer programming courses.	1, 5, 6
[9]	Evaluation criteria for the selection of apps used for teaching. Develop methods to support and educate preservice teachers about the use of these technologies. K–12 teacher education program: math, science, English language education, and computer education.	1, 2
[10]	Assessment of usability and utility of mobile applications for teaching anesthesiology in a public hospital.	7
[11]	Development and evaluation of teaching tools for Geo-education in middle and high schools.	2
[12]	Development of interactive training simulator HIS (hospital information system) and evaluation of its role in improvement of HiT (health information technology) students' informatic skills.	8
[13]	Evaluation of e-platform TELMA for medical staff. Use of e-MIS validity methodology used to measure the three dimensions of web quality.	2, 9, 10
[14]	Keystroke Level Model-Form Analyser (KLM-FA) tool to support automated evaluation of web form filling tasks using human performance models usability evaluation for learning purposes and the use of a product for teaching. Teaching of HCI concepts (computer science).	2, 7
[15]	Combination method to generate Knowledge management system (KMS) that meets user requirements. The system prototype is evaluated by measuring user satisfaction using the Post Study System Usability Questionnaire. Study tackles education issues, specifically, teaching assistant problems at the Faculty of Computer Science.	11
[16]	Feedback-enriched simulation environment (FENIkS) for learning fundamental UI design principles usability evaluation to measure its appropriateness with respect to learning and the use of a product for teaching. Teaching UI design principles toward designing the functional aspects of a UI.	12
[17]	Systematic mapping study about teaching major Software Engineering Trends in project courses.	-
[18]	Use of developed web tool for evaluation of nursing students' competences, clinical experience and satisfaction.	2
[19]	Augmented reality system use with benchtop models in medical schools with the aim of addressing the problem of lack in visualization. Present systems evaluation results. Medical schools (Digital Rectal Examination).	2
[20]	Development of a communication process assessment tool for Year one undergraduate pharmacy students. Stage 3 assessment to investigate the revised tool's inter-rater reliability and to determine impact on usability. Medical schools (undergraduate pharmacy students).	2
[21]	Development of individual testing according to student learning style using ontology and applying the Methontology methodology. Following approach used to achieve personalisation of the training process. Usability of the developed tool was evaluated.	1
[22]	Augmented reality mobile application for teaching accounting ethics for university students using revenue recognition case conduct pre- and post-tests on the SUS to measure perceived usability. Ethics education in business schools.	7
[23]	Game which educates the player on the basic concepts of programming and object-oriented programming through Java. Students evaluated the game in terms of its usability, confidence in playing the game, challenge, satisfaction, fun, focused attention and relevance.	2

1- heuristic analysis, 2 - tests with users (survey method), 3 – own method (visualising the website's elements and user interactions [4]), 4 - cognitive walkthrough usability evaluation method, 5 - tests with users (SUMI questionnaire [24])), 6 - tests with users (ergonomic criteria [25]), 7 - tests with users (System Usability Scale (SUS)[26]), 8 - tests with users (QUIS questionnaire [27]), 9 - tests with users (web analytics method (KPI1: clicks per task (number), KPI2: task performed (%), KPI3: time per task (seconds), KPI4: clicks per functionality (number) and KPI5: efficiency (parts per unit, where 1 is the maximum and 0 is the minimum) [13]), 10 - tests with users (checklist method), 11 - tests with users (Post Study System Usability Questionnaire (PSSUQ)[28]), 12 - tests with users (Computer System Usability Questionnaire (CSUQ) [29]).

Comparative analysis of 19 articles showed that the authors of 5 articles [4], [6], [8], [9], [21] used Heuristic evaluation. Authors of article [6] additionally used the cognitive walkthrough usability evaluation method. Furthermore, authors of 18 articles used tests with users using different methods: 1. Survey method (SUMI [24], ergonomic criteria [25], SUS [26], QUIS questionnaire [27], PSSUQ [28], CSUQ [29], own questionnaire); 2. Web analytics method; 3. Checklist method; 4. Own method.

The authors of 16 articles present a usability evaluation of the tool, which allows them to determine its suitability for learning and the use of the product for teaching. In article [4] the authors present their own teaching method applied in a usability research course - visualisation techniques of the user-website interaction. In [9] the authors presented a developed method that allowed them to define the evaluation criteria for the selection of apps used for teaching. In [17] the authors showed a systematic mapping study about teaching major Software Engineering Trends in project courses. They classified 126 papers based on their investigated Software Engineering Trends, according to: Software Engineering processes and practices, teaching approaches, and the evolution of Software Engineering Trends over time. Furthermore, it was determined that 79.4 % of studies are linked to SE (Software Engineering) trends, precisely of Agile Software Development, Software installation. Articles about Usability and Value are the second largest group, making 16.7 % of analysed articles. Authors have concluded, even though software installation, usage and value trends are discussed in most articles, yet the topic still remains mostly overlooked.

This literature review reveals that there are a number of initiatives to evaluate information system usability, yet no methodology was found which would allow to assess high school students' learning including them into a project of information system usability testing. Detailed overview of methodology is described in the following section.

3.2 Analysis of the events on the information system usability evaluation

In the following section authors present the results of usability evaluation performed by students, with detailed results of their examination according to the type chosen (standard or project integrated).

3.2.1 Heuristics for Usability Evaluation

During the first round of testing students defined each encountered defect event, which later was systemized to create a well defined set of heuristics. List of Heuristics comprised: (1) Input validation - Verification of input data; (2) Navigation/ Management - Navigation and control, status visibility; (3) Absent function - there is no function; (4) Malfunctioning - a programming error message or a function is not executing or executing incorrectly; (5) Recognizability - the user recognizes the element or predicts the result of the element's action; (6) Robustness - user support; (7) Element color/position - colors and shapes of elements, location in the interface; (8) Classifiers/Flexibility - classifiers, flexibility of the system, ways to perform the task; (9) Writing - grammatical or writing error; (10) Violation of rights - without permission, infringement of rights.

In second and third rounds of testing, in addition to the defined heuristic in round one, two items were added "11. No defect - not a defect, for describing positive aspect with Nelson heuristics;" and "12.Other - other, for describing defect with Nelson heuristics". Students who wanted to use Nelson heuristics to record system defects could select it under item "12.Others". For the definition of positive aspect Nelson's heuristics should have been used and defined under the item "11.No defect".

3.2.2 Analysis of the events recorded in the information system usability evaluation

During the second testing round of information system usability, students recorded events of all heuristic types. Distribution of event types was following: 27.9% positive aspects and 72.1% defects from the set of all events. It was clearly biased toward finding defects (1-10 and 12) as it was more noticeable, while positive aspects (11. "No defect") are harder to describe and link to heuristics, thus there are more defects. Nelson's heuristics were used less than the authors' heuristics (Fig. 2).

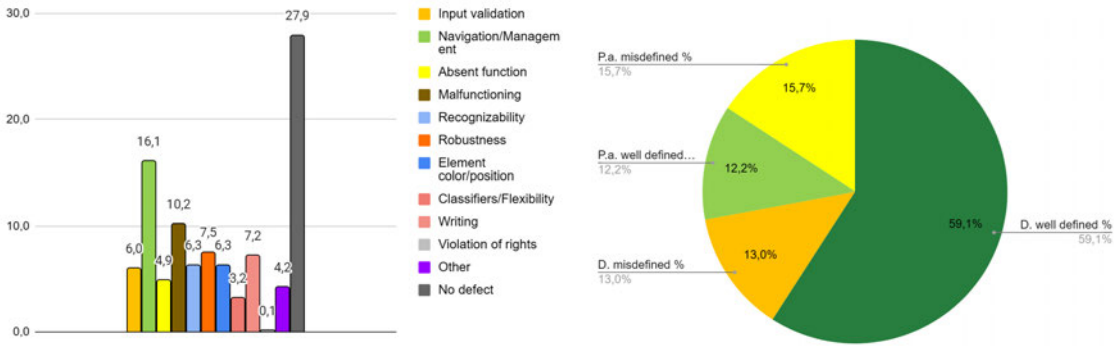

Figure 2. Events percentage distribution by heuristics in 2021.

The pie chart shows the distribution of events and the quality of the assignment of the heuristics. 59.1% of all events were well-defined defects with correctly assigned heuristics, while 13% of events were defects with misdefined heuristics. Positive aspects accounted for a smaller proportion of all events, with half of them being well-defined at 12.2% and the other half being misdefined at 15.7%. From the diagram, it can be seen that the students made less mistakes when defining the defects (59.1% correctly defined defects), than when defining the positive aspects of the system (12.2% correctly defined positive aspects).

During the third round of testing the usability of a system [30], students also recorded events of all heuristics. There was also correlation with having more defects (65.2% of events) than positive aspects (34.8% of events) detected. Students as well used Nelson heuristics for defect recording – 4.8% of events (12. “Other”), and for positive aspects – 34.8% of events (11. “No defect”) (Fig. 3).

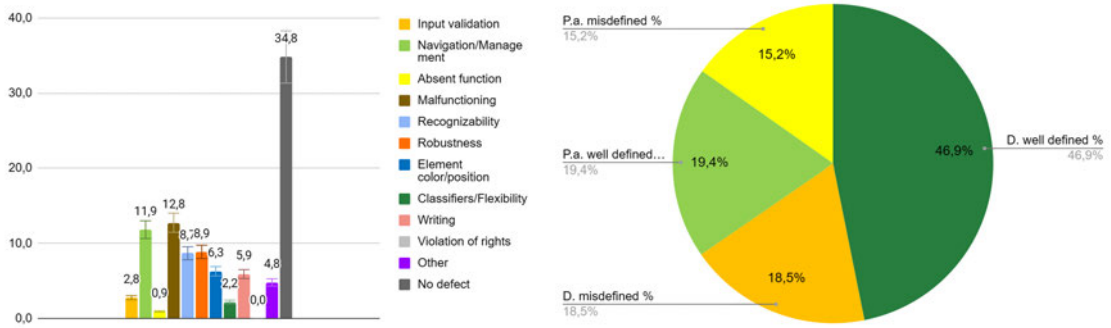

Figure 3. Events percentage distribution by heuristics in 2022.

In the 3rd round 46.9% of all events were well-defined defects with correctly assigned heuristics, while 18.5% of events were defects with misdefined heuristics. Positive aspects accounted for a smaller proportion of all events, with half of them being well-defined at 19.4% and the other half being misdefined at 15.2%. Consistent with the second round, it can be seen that the less mistakes were made defining defects rather than positive aspects.

3.3 Students learning assessment results from the system usability evaluation studies

Students performing usability evaluation of an information system could choose the form in which they would be evaluated: a standard exam (E. standard form) or the ability to evaluate the usability of an information system in a real project (E. new form).

3.3.1 Students learning assessment results of 2nd testing round in 2021 year

The results show that students were more motivated to take the project integrated examination (79% of all students, Figure 4) than in a standard exam (21% of students, Fig. 4). Students who evaluated the usability of the system mostly received grades 7 and 8 (out of 10) (22.4% of students for both groups). On the other hand, most students who chose to take the standard exam received lower grade 6 (out of 10) (9% of students).

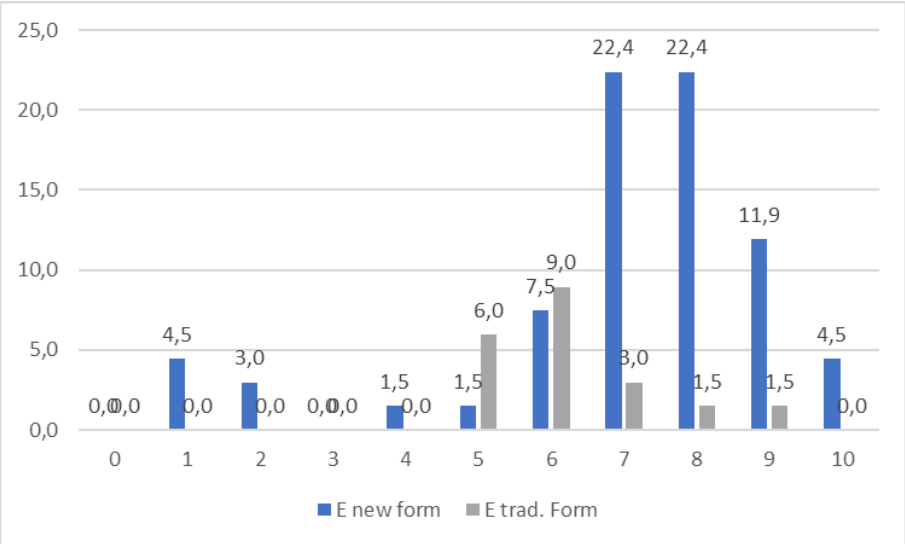

Figure 4. Percentage distribution of student assessments by types of evaluation forms in 2021.

3.3.2 Students learning assessment results of 3rd testing round in 2022 year

Similar to the 2nd round, the results of the 3rd testing round also showed that students were more motivated to take the project integrated examination (89,6% of students, Fig. 5) than in a standard exam (10,4% of students, Figure 5). Students who evaluated the usability of the system mostly received grades 6 and 7 (out of 10) (21.1% and 18.4% of students). Students who chose to take the standard exam received lower grades - 1, 2, 5 and 6 (2.6% of students, for each group).

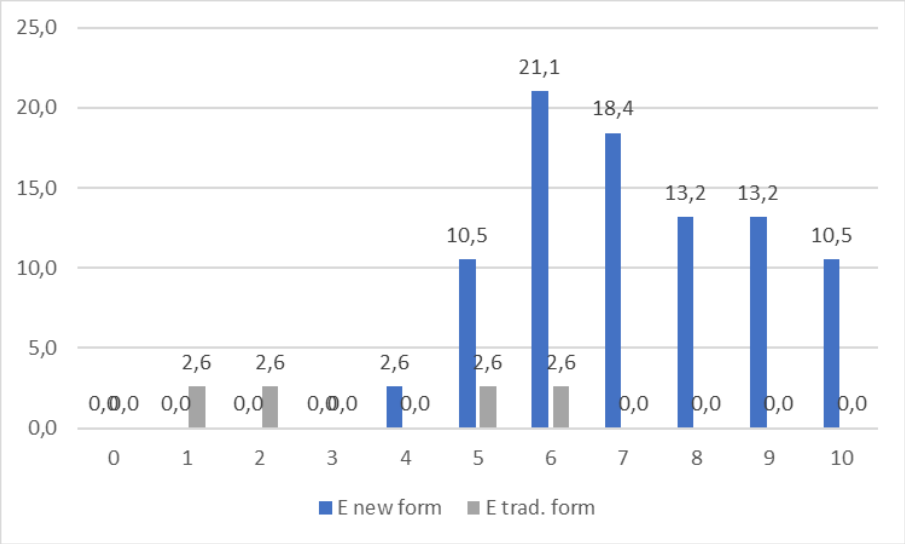

Figure 5. Percentage distribution of student assessments by types of evaluation forms in 2022.

4 CONCLUSIONS

During the first round of testing, the authors systematized and defined a set of heuristics based on the students' description of the defects. In the second round students assessed the usability of the system being developed using a combined method. In the third stage, the assessment of methodology was repeated. The assessment made by students was graded as part of an examination.

1 Analysis of events found during information usability evaluation showed that for students it was easier to evaluate defects than positive aspects of the information system (72.1% and 65.2% of all events found in second and third rounds respectively). Furthermore, students made less mistakes while assigning defects to heuristics rather than positive aspects of the system (59.1% and 12.2% correctly defined defects and positive aspects respectively during second testing

round; 46.9% and 19.4% correctly defined defects and positive aspects respectively during third testing round).

2 Detailed analysis of event logs have revealed that students found Nelson heuristics more complicated and preferred to use authors' heuristic instead. Nelson's heuristics were used in 4.2% defects and 27.9% positive aspects of all events during the second round of testing, 4.8% and 34.8% respectively during the third round of testing.

3 Results of students' assessments indicated that students were more motivated to participate in project integrated rather than standard type of examination (79% and 89.6% of all students chose project integrated examination in second and third rounds of testing respectively).

4 It has become clear that students who have decided to take the project integrated examination mostly received better grades than those who had taken the standard examination. Students that participated in the project received grades 7 and 8 (out of 10) (22.4% in both groups) and grades 6 and 7 (21.1% and 18.4% respectively) during second and third rounds of testing respectively. Students who choose to take the standard exam did worse during their examination. Most have received grades 6 (9%), and 1, 2, 5 and 6 (2.6% in all groups) during examination of respective years of second and third rounds.

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