Students' Testing Preferences in Mathematics

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Abstract

Using a web-based environment for assessment can provide several advantages and disadvantages for both academics and students. The purpose of this study is to examine university students' testing preferences in mathematics comparing their views on web-based and paper-based assessment. Two groups of engineering students, daytime and distance learners, were studied about their preferences and rationale. Based on the survey, statistical hypotheses were formulated and validated using chi-squared test statistics for categorical data. The results of this study showed that the vast majority of respondents thought that an opportunity to take web-based assessment tests in math was a good innovation. However, there were no statistically significant differences between the percentages of students who preferred to take assessment tests in math on computer, or on paper, or it did not matter to them. Those students who preferred to take web-based assessment tests were generally in favour of the replacement of paper-based classroom assessment tests with web-based tests, and vice versa. Those students who did not care whether to take paper-based or web-based assessment tests were in favour of partial replacement. The students' willingness to replace web-based homework with paper-based tasks only slightly depended on their preferences. Qualitative content analysis was used to analyse open questions. The research has shown that the reasons for the learners' preferences were mostly related to convenience and flexibility, environmental sustainability, complexity and academic fraud.

Keywords: students' preferences; higher education; web-based testing; paper-based testing; survey

1. Introduction

The engineering curriculum is based on the development of technical knowledge and skills that can be assessed to a certain extent through testing. According to Albanna and Abu-Safe (2019) and AbdulRasheed and Iyere (n.d.) the rapid development of information and communication technologies (ICT) has shifted the paradigm from paper-based to web-based testing. One reason for this change could be the decreasing number of contact lessons, which has increased the necessity to use face-to-face meetings as efficiently as possible. Finding a way to support the students' learning is an important concern in higher education. Several comparability studies examining the transfer of tests from paper to web-based environment have been conducted. Such studies have been focused rather on the advantages and disadvantages (Clariana and Wallace, 2002), (FutureEd, 2018), (Albanna and Abu-Safe, 2019), (Miller, 2019) or on the performance (Al-Amri, 2008), (Özalp-Yaman and Cagiltay, 2010), (Candrlic et al., 2014), (Barros, 2018), (AbdulRasheed and Iyere, n.d.) than on the students' preferences. This study focuses primarily on the perspective of students.

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The next section briefly presents the courses where students were assessed, and the structure of the assessment tests. In the section on Materials and Methods, the used methods and characteristics of the participants are described. The results of the study are discussed in the section on Results. Comparisons with other researchers' work and some suggestions are presented in the section Discussion, and conclusions are provided in the section Conclusion.

2. Background

This study was conducted with participants of the courses of Mathematics II and Applied Mathematics in TTK University of Applied Sciences in 2018-2019.

The aim of the courses is to provide first year undergraduate students with a general overview of the basic themes and issues in higher mathematics. The subjects Mathematics II and Applied Mathematics cover a common core of basic topics from Linear Algebra, Analytic Geometry and Calculus such as matrices and determinants, systems of linear equations, vector algebra, straight lines and planes, quadratic curves, functions of one variable and limits, differential and integration calculus with applications. The material of those courses is absolutely fundamental to nearly all areas of natural and engineering sciences. During these courses students develop their logical and as well as mathematical thinking ability.

The assessment system used in these courses is described below. Five assessment tasks are required to complete the courses. These are: two paper-based classroom assessment tests, two home web-based tests and one classroom web-based test.

Both types of assessment tasks (paper-based and web-based tests) provide information about the students' abilities to perform typical mathematical procedures, they also involve higher-level thinking and problem-solving skills, represent meaningful academic activities and include real-world applications.

Paper-based assessment is in the form of a traditional classroom test which the student takes using paper, a pencil and a handheld calculator. A full solution is required.

Web-based assessment tests include both selected-response elements - such as matching, multiple choice and true/false questions, and constructed-response elements - such as problems to solve step by step or fill in the blank questions. Web-based tests are performed in Moodle environment. The tests are built in a flexible way so that the student can answer the questions one by one instead of taking the whole test at once. Each test has two attempts, an average score is counted.

3. Materials and Methods

The survey was designed to compare the students' preferences toward web-based testing versus paper-based testing. A target group of the survey consisted of daytime and distance first-year students who attended mathematics courses at TTK University of Applied Sciences in 2018-2019. The questionnaire was prepared to obtain data within the scope of research and it was applied to 167 daytime and 37 distance students. The total amount of students in the sample was 201. A personal information form prepared by the researchers in Google Forms was used as a data collection tool. All responses were collected anonymously.

During the survey students were asked to answer the following multiple-choice questions:

1. What do you think about the opportunity to take web-based assessment tests in mathematics? The possible answers are: this is a good innovation, this is a bad innovation.
2. How do you prefer to take assessment tests in mathematics? The possible answers are: on computer, on paper, it does not matter.
3. Do you think it is a good idea to replace paper-based classroom assessment tests in mathematics with web-based tests? The possible answers are: yes, no, partially.
4. Do you think it is a good idea to replace math web-based homework with paper-based homework? The possible answers are: yes, no, partially.

The data analysis of the responses, obtained during the survey, was conducted by using chi-squared test for categorical data. Based on the survey, statistical hypotheses were formulated and their validity was checked using chi-squared test statistics and the Cramer's V coefficient. The significance level of $p < 0.05$ was accepted as the statistical significance. For data analysis R-statistical software in conjunction with R-commander was used.

Qualitative content analysis was used to code the open questions in the survey. The students were asked to explain their responses to the above questions 2, 3 and 4, and to the following open questions:

1. What do you think the benefits of web-based assessment tests are?
2. What do you think the drawbacks of web-based assessment tests are?

Themes were used as a unit of analysis to create categories from the students' phrases. A coding table was created using MS Excel software which was also used as the environment for data analysis.

4. Results

4.1. Results of statistical analysis

Looking at the frequency and percentage distributions of data obtained, it is observed that the vast majority of respondents (91.54%) thought that the opportunity to take assessment

tests in math on computer was a good innovation. 34.83% of respondents were in favour of the replacement of paper-based classroom assessment tests with web-based tests, 11.44% of respondents were not in favour of the replacement, and 53.73% were in favour of partial replacement. 12.94% of the respondents were in favour of the replacement of math web-based homework with paper-based homework, 65.67% of respondents were not in favour of the replacement, and 22.39% were in favour of partial replacement. No statistically significant differences were found between the opinions of daytime and distance students in any questions of the poll.

Table 1: Frequency and percentage distribution of the answers given to the question “How do you prefer to take assessment tests in mathematics?”

	Form of study		
Preference	Distance	Daytime	Total
On computer	16 (47.06%)	65 (38.92%)	81 (40.30%)
On paper	7 (20.59%)	45 (26.95%)	52 (25.87%)
It does not matter	11 (32.35%)	57 (34.13%)	68 (33.83%)
Total	34 (100%)	167 (100%)	201 (100%)

The following statistical hypotheses about the form of the distribution of the observations in Table 1 were formulated and tested:

the relevant null hypothesis H_0 : the distribution of the observations in Table 1 follows the distribution in the form of 1/3-1/3-1/3;

the alternative hypothesis H_1 : the distribution of the observations in Table 1 does not follow the distribution in the form of 1/3-1/3-1/3.

Table 2: The p-values of chi-squared test calculated for different types of students

Form of study	p-value
Daytime students	0.162 > 0.05
Distance students	0.1663 > 0.05
All students	0.0429 < 0.05

In Table 2 the empirical p -value of the sample is slightly lower than the critical value for both forms of study. But for daytime and distance students considered separately the p -values are not less than the chosen significance level 0.05. Thus, the null hypothesis H_0 was confirmed, and for the data this means that there are no statistically significant differences between the percentages of students who prefer to take assessment tests in math on computer, or on paper, or it does not matter to them.

The statistical hypotheses about statistical independence of the variables in Table 1 were formulated and tested. It has been observed that there is no statistically significant difference in the preferences of daytime and distance students (the empirical p -value is $0.6275 > 0.05$).

Table 3: Frequency and percentage distribution of the answers given to the question “Do you think it is reasonable to replace paper-based classroom assessment tests in math with web-based tests?”

	Form of study		
Responses	Distance	Daytime	Total
Yes	14 (41.18%)	56 (33.53%)	70 (34.83%)
No	4 (11.76%)	19 (11.38%)	23 (11.44%)
Partially	16 (47.06%)	92 (55.09%)	108 (53.73%)
Total	34 (100%)	167 (100%)	201 (100%)

Table 4: Frequency and percentage distribution of the answers given to the question “Do you think it is reasonable to replace math web-based homework with paper-based homework?”

	Form of study		
Responses	Distance	Daytime	Total
Yes	6 (17.65%)	20 (11.98%)	26 (12.94%)
No	22 (64.71%)	110 (65.87%)	132 (65.67%)
Partially	6 (17.65%)	37 (22.16%)	43 (21.39%)
Total	34 (100%)	167 (100%)	201 (100%)

The statistical hypotheses about statistical independence of the variables in Tables 3 and 4 were formulated and tested. The corresponding empirical p -values were found to be not less than the chosen significance level 0.05 ($p = 0.6647$ for the Table 3 and $p = 0.6137$ for the Table 4). In both cases the corresponding null hypothesis about independence of variables was confirmed. For the data it means that in Tables 3 and 4 no dependence between responses on the questions and the students’ form of study was established.

In Tables 5 and 6, the rows indicate the students’ preferences for assessment tests in math, and the columns represent the students’ responses on the third and the fourth question, respectively.

Table 5: Frequency and percentage distribution of the answers given to the question “Do you think it is reasonable to replace paper-based classroom assessment tests in math with web-based tests?” depending on the students’ preferences

	Responses			
Preference	Yes	No	Partially	Total
On computer	54 (77.14%)	2 (8.69%)	25 (23.15%)	81 (40.30%)
On paper	4 (5.71%)	15 (65.22%)	33 (30.56%)	52 (25.87%)
It does not matter	12 (17.14%)	6 (26.09%)	50 (46.29%)	68 (33.83%)
Total	70 (100%)	23 (100%)	108 (100%)	201 (100%)

Table 6: Frequency and percentage distribution of the answers given to the question “Do you think it is reasonable to replace math web-based homework with paper-based homework?” depending on the students’ preferences

	Responses			
Preference	Yes	No	Partially	Total
On computer	10 (38.46%)	56 (42.42%)	15 (34.88%)	81 (40.30%)
On paper	11 (42.31%)	26 (19.70%)	15 (34.88%)	52 (25.87%)
It does not matter	5 (19.23%)	50 (37.88%)	13 (30.24%)	68 (33.83%)
Total	26 (100%)	132 (100%)	43 (100%)	201 (100%)

The statistical hypotheses about statistical independence of the variables in Tables 5 and 6 were formulated and tested.

The empirical p -value for Table 5 was found to be $3.295e-15 < 0.01$. Thus, the null hypothesis H_0 was rejected in favour of the alternative hypothesis H_1 about dependence of variables. The Cramer’s V coefficient for Table 5 was found to be 0,429. For the data this means that students who preferred to take assessment tests on computer were generally in favour of the replacement of paper-based classroom assessment tests with web-based tests, and vice versa, those who preferred paper-based assessment tests were not in favour or were partially in favour of the replacement of paper-based classroom assessment tests with web-based tests. Those students for whom it did not matter whether to take paper-based or web-based tests, were in favour of the partial replacement of classroom paper-based tests with web-based tests.

The empirical p -value for Table 6 was found to be $0.06275 < 0.1$. The null hypothesis H_0 was rejected in favour of the alternative hypothesis H_1 about dependence of variables (with significance level 0.1). The Cramer’s V coefficient for Table 6 was found to be 0,149. For the data this means that the students’ willingness to replace math homework on computer with paper-based homework only slightly depended on their preferences.

4.2. Results of content analysis

The students were asked to explain the benefits and drawbacks of web-based assessment tests and to justify the rest of their answers. The students' rationale for their preferences is outlined below. It was interesting that just a few students who did not prefer web-based testing explained their preferences. Those students stated that they understand the modern character of web-based testing but that it seemed unfamiliar to them.

The responses revealed four main factors that explained both the positive and negative aspects of web-based assessment tests. The positive factors are convenience and flexibility and environmental sustainability. Complexity and academic fraud were mentioned as negative factors.

The dominant factor that became clear from the students' answers was the convenience and flexibility of web-based tests. The respondents emphasised the importance of being independent of time and place, and that there was no time limit for completing the tests like in the classroom. This makes testing less stressful and students believe that web-based tests help to rationalise lecture time. The students also liked the form of web-based tests: there is no need to write, answers are provided, answering and feedback are quick and it is possible to take the tests repeatedly. Web-based tests were seen as an opportunity to reduce fingerprinting. The respondents also highlighted the possibility of individualising tests: automatically generated test questions and a different test for each student. Testing was also reviewed from the teacher's perspective, meaning that it is quicker and more convenient to assess web-based tests because it does not depend on the understanding of handwriting.

The complexity mostly stems from old habits but also from technical problems and limitations. The technical problems include Internet connection issues, power failures, computer crashes and server problems, which prevent performing tests at the desired time. Technical limitations could be connected with the level of precision the answer has to be entered and it is easier to calculate on paper, also difficulties to enter special characters, an accidental shutdown of a working window, no solution can be shown, more difficult to write, accidental wrong choice of an answer and MacBook restrictions. It was also pointed out that in web-based tests it was more difficult to check the answers because the students did not find their own mistakes and did not understand them. The students mentioned that this made it more difficult to concentrate on the task, reduced their motivation to calculate more difficult tasks and complicated starting with the tests. One more aspect that affects the students' opinions is that it is impossible to ask the teacher for immediate help.

The next factor is academic fraud. The students did not like that somebody else could take the test and it was easy to use additional materials and online calculators that made results incomparable.

Students also highlighted the environmental sustainability factor of web-based tests in terms of saving paper, toner and pens.

5. Discussion

This study examines university students' preferences and rationale towards web-based and paper-based tests. There are a number of researchers studying students' preferences on the issue of online assessment. The results of these studies are sometimes contradicting.

For example, Khan and Khan (2018) study shows that students do not understand the usefulness of the transition to web-based assessments. They also found that for students the norm was traditional assessment methods and they have to be assured of the benefits of the transition to web-based tests before they accept it to the fullest.

Nugroho et al. (2017) studies argued that social anxiety disorder has hindered students in performing their best during an examination using computer-based assessment method. It might be the reason why the students do not favour web-tests as the tool for final assessment. Medina and Castleberry research (2016) has shown that students' greatest concern with computer-based testing is technology-related difficulties, such as the inability to access an exam and network connectivity issues.

Albana and Abu-Safe (2019) established that no significant difference could be drawn between students' attitude based on their gender or also based on the frequency of their access to computers, and positive attitude to the computer-based testing depends on the student's access to the computer. Claire (2012) study showed a fairly even split in terms of preference for online, offline, or either no strong preference modes.

On the other hand, Miettunen (2018) claims, based on the students' feedback, that students prefer web-based exams, and web-based exams prove to be a step towards a student-centred and constructivist learning. Barros (2018) also indicates students' overwhelming preference for web-based tests compared to paper-based tests. Candrlie et al. (2014), based on students' comments received during the study, concluded that students prefer to use the keyboard rather than a pencil so they would rather take web-based tests than paper-based tests.

De-Siqueira et al. (2009) found that most students prefer writing on computer-based tests than paper-based tests, because it permits them to save a considerable amount of time. According to Okocha et al. (2017) the majority of students have a positive attitude towards computer-based assessment, but most of the respondents indicated the need for training on the use of such type of knowledge control, they need new habits and skills. The same study showed that students studying physics and chemistry showed preference for paper based testing method, emphasising the interface of web-based tests to be improved. This can be explained by the fact that students in both chemistry and physics have to use special symbols.

According to Mukandutiye, et al. (2014), students prefer web-test because they find it appropriate and less stressful, and because they can have their assessment results instantly. Conducive environment provided by the system and receiving feedback automatically using the computer-based assessment system was regarded by students as a positive experience. On the other hand, students feel the urge for tutorials to familiarise them with the testing environment (Jimoh, 2012).

According to Kirkova-Bogdanova et al. (2015) students explained their choice of computer-based testing with saving supplies and with saving time. But the paper-based test was preferred because of the possibility for better concentration and old habit.

Also Bennedsen and Caspersen (2006) argued that “paper-based tests are used due to tradition, fraud prevention, and the additional resources needed to properly apply computer-based tests”.

Jamiludin et al. (2017) point out that students prefer to use web assessment because they will not be required to bring any writing tools such as pencils, erasers, a ruler. But students also emphasised that the computer operation really relies on particular circumstance like electricity and the internet to run web-test.

The findings of this study contribute to the literature on assessment by providing additional evidence that students’ preferences are consistent and they are different among learners. The results of the study also explain the reasons behind student preferences to better meet the needs of students.

6. Conclusion

The study showed that the opportunity to take assessment tests in math on computer was a good innovation. However, there was no clear preference for how the students would like to take the assessment tests. The preference influenced the readiness to bring paper-based tests to web-based environment but the students’ willingness to replace math homework on computer with paper-based homework depended only slightly on their preferences. It has been stated that no statistically significant difference has been found between the opinions of daytime and distance students in any questions of the poll. Convenience and flexibility, environmental sustainability, complexity and academic fraud influenced learning preferences. To promote students’ satisfaction, teachers should be advised to promote assessment tests according to students’ preferences offering more opportunities to perform assessment tests and reduce the negative aspects of web-based tests. All of these can lead to a positive impact on learning.

The results should be considered with some limitations. The small number of respondents does not allow to generalise the results. The study is limited to first-year undergraduate engineering students participating in math courses. Subsequent studies may include more university disciplines and increase clearness and generalizability.

Future research will focus thoroughly more on how to improve web-based tests, their structure, format and presentation. Future research will also investigate the relationships between students’ testing preferences and their performance. As the authors have started using STACK questions in the tests, there is need to continue to investigate whether these questions provide more information and support for students in taking the tests.

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