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UsabilityZero: Can a Bad User Experience Teach Well?

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Abstract. Interfaces with good usability help their users complete more tasks in less time and with less effort, which gives them greater satisfaction. Given the vast array of options available to users today, usability is an important interface feature that may lead to the commercial success or failure of a software system. Despite its importance, few educational tools are available to help usability teachers and students. Knowing how to measure interface usability is one of the basic concepts that students should learn when they study the theme. This paper presents UsabilityZero, a web application to support the teaching of usability concepts to undergraduate students. By using UsabilityZero, students interact with a system displaying a reduced usability interface and, later, with the same system exhibiting an increased usability interface. Considering the use of UsabilityZero by 64 students, the differences between the interface with reduced and increased usability were: (i) 61.5% decrease in the number of clicks; (ii) 62.2% decrease in the time to perform tasks; (iii) 92.9% effectiveness increase; and (iv) a 277.3% satisfaction increase. During their experience with UsabilityZero, students learn how to measure efficiency, effectiveness, and satisfaction of user interfaces. After using the application, Information Systems and Computer Science students who had never been in touch with the subject could identify key usability aspects. The students' perception of efficiency, effectiveness, and satisfaction as usability measures was higher than 80%. Also, they could identify some usability criteria and understand how measurements change when some of them are present in the interface design. As a result, over 92% of these students said they recognized the importance of usability to the quality of a software product, and 79% declared that their experience with the application would contribute to their professional lives.

Keywords: software engineering, human-computer interaction, usability, teaching tools.

1. Introduction

One advantage of interfaces with good usability is user welfare (Cybis *et al.*, 2010). When interacting with poorly designed interfaces, users tend to get frustrated with the decrease in productivity and the excess of mistakes made. Also, software applications are useless to users that cannot understand how to manipulate them (Polack-Wahl, 2004). Well-designed interfaces improve the way users interact with their devices, affording effectiveness, efficiency, and satisfaction because they can complete their work with quality and in a satisfactory time. That is why the design of the interface is as important as that of other parts of the system.

Usability is part of the broader Human-Computer Interaction (HCI) area that researches how people use computers and design technologies that let them interact in novel ways. HCI classes are present in the Curriculum Guidelines for Undergraduate Degree Programs for Computer Science (ACM/IEEE-CS, 2013), Information Systems (Topi *et al.*, 2010), and Software Engineering (on Computing Curricula, 2015). Despite having its importance recognized by academia, there seems to be a lack of literature on practice-level issues about its implementation in the classroom (Chong, 2017). Likewise, technological tools specifically designed to aid HCI teaching are practically nonexistent (Benitti and Sommariva, 2012; Lima and Benitti, 2019), limiting the options educators have to adapt existing solutions (Dix *et al.*, 2016) and to explore active learning alternatives (Lima and Benitti, 2019). The conception of specific solutions could contribute to learning by adding other factors, such as motivational aspects related to serious games, for example, in addition to increasing the resources available to teachers to promote diverse and participatory classes.

Benitti and Sommariva (2012) executed a systematic mapping study to search for games and simulators specifically developed to support usability classes, but their research found no tool designed for that purpose. They later proposed and developed a serious game, called UsabilityGame (Benitti and Sommariva, 2015), to offer students the opportunity to practice the usability life cycle by addressing requirement analysis, prototyping, and heuristic evaluation. Later, Lima and Benitti (2019) carried out a systematic mapping study to get an overview of HCI classes at the undergraduate level, investigating how HCI is taught and what tools exist to support the process. Besides UsabilityGame, the authors found only one other tool specifically designed to teach HCI: WOZ Pro (Wizard of Oz Prototyper; Hundhausen *et al.*, 2012), a low-fidelity prototyping environment for prototype creation and wizard of oz testing.

It is in this scenario, understanding the importance of usability for user interfaces and noting the lack of computational solutions available to support the teaching/learning process, that this article aims to contribute. Here, we present UsabilityZero, a web application to support usability teaching. It is a tool that uses a "by example" approach to expose the differences between two given user interfaces, one with deliberately reduced usability and another interface that applies some criteria that can make it easier for the users to finish their tasks in less time and with less effort. UsabilityZero should provide a user experience that enables students to achieve the following learning objectives:

- Recognize the importance of usability for a software product.
- Recognize usability criteria.
- Recognize usability measures.

The following section of this paper discusses the usability measures and criteria that are highlighted by the application. We present the UsabilityZero application in Section 3. Section 4 brings the evaluation of our solution, and we present our conclusions in Section 5.

2. Background

The new version of ISO 9241-11 (ISO 9241-18, 2018) defines usability as “the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use”. ISO 9241-18 (2018) highlights three important usability measures, effectiveness, efficiency, and satisfaction, that can be objectively estimated.

Nielsen (2001) defined effectiveness in terms of user success rate, i.e., by the percentage of tasks a user correctly completes. Besides the correct and complete execution of the task, we can also take into consideration its partial execution or with some deviation from the original goal.

Efficiency is the number of resources a system demands from users to execute their tasks. The fewer resources users need to achieve the same result, the more efficient the system is. These resources can either be the time users spend to complete their tasks or the number of clicks they need to reach their goals. Both can measure the efficiency provided by user interfaces (Nielsen, 2012a; Shneiderman and Plaisant, 2009).

Satisfaction relates to “positive attitudes, emotions and/or comfort resulting from use of a system, product or service” (ISO 9241-18, 2018). Since it is an inherently subjective criterion, one way of measuring it can be with the application of an appropriate standardized questionnaire (Nielsen, 2012b).

Two of the most popular standardized questionnaires used to assess perceived usability are the Computer System Usability Questionnaire (CSUQ) and the System Usability Scale (SUS), both in the public domain, with no license fee required for their use. However, Lewis (2018) demonstrates that “the CSUQ is popular, but the SUS is almost three times as popular.” Despite having been independently developed and containing different item content and formats, the SUS and CSUQ related questionnaires largely appear to be measuring the same thing, presumably, perceived usability. Not only were they strongly correlated, but their mean scores also had similar magnitudes and similar grades when converted into a standard 0-to-100-point scale (with 0 meaning *poor* and 100 meaning *excellent*) (Lewis, 2018). For these reasons, we chose to incorporate the SUS questionnaire into our solution.

System Usability Scale (SUS) has ten questions to be answered on a value scale from 1 (strongly disagree) to 5 (strongly agree). An acceptable score on the SUS questionnaire must be at least 55 of 100 points (Bangor *et al.*, 2008).

Considering that the goal is to get good measures of effectiveness, efficiency, and satisfaction, it is important to know how to design interfaces that enable their users to get them. One way is to follow some principles or criteria that are already well accepted and recognized. Among the most popular criteria are Jakob Nielsen’s *Usability Heuristics* (Nielsen, 1995), Ben Shneiderman’s *Golden Rules* (Shneiderman, 2016), and Bastien & Scapin’s *Ergonomic Criteria* (Bastien and Scapin, 1993). Another important set of usability criteria is the *Dialogue Principles*, presented by ISO 9241 (ISO 9241-110, 2006). Table 1 correlates the criteria introduced by each of those sources, and it is easy to see that there is much in common among them. Five of the criteria are common to

Table 1
Usability Criteria Comparison Table

Shneiderman	Nielsen	Bastien & Scapin	ISO 9241
Prevent errors; Permit easy reversal of actions	Error prevention	Error protection; Error correction	Error tolerance
Strive for consistency	Consistency and standards	Consistency	Conformity with user expectations
Offer informative feedback	Visibility of system status	Immediate feedback	Self-descriptiveness
Cater to universal usability	Flexibility and efficiency of use	User experience; Flexibility	Suitability for indvidu-alization
Reduce short-term memory load	Recognition rather than recall	Brevity	
Put users in control	User control and freedom	Explicit user action; User control	Controllability
	Help users recognize, diagnose, and recover from errors	Quality of error mes-sages	
	Aesthetic and minimalist design	Information density	
	Match between system and the real world	Significance of codes	
	Help and documentation		Suitability for learning
Design dialog to yield closure			Suitability for the task
		Prompting	
		Compatibility	
		Grouping/Distinction by location	
		Legibility	

all four sets while one other is present in three of them. Our application UsabilityZero highlighted these six most common criteria. We describe them below:

1. **Error Handling (prevention and correction)**: Preventing errors from being made or correcting them after detection should always be taken into consideration when designing an interface; Errors are unwanted, for they decrease productivity and frustrate the user.
2. **Consistency of interface elements**: When the user interacts with an interface, he naturally expects similar objects to behave similarly.
3. **User Feedback**: For the vast majority of users the computer is a mysterious machine; Knowing what is happening helps the user deal with it.
4. **User Adaptation**: Computers and their systems are designed to cater to humans. Therefore, interfaces must adapt to the diverse needs and skills of their users, not the other way around.
5. **Workload Reduction**: As a tool, the computer should assist the user in performing their tasks efficiently by reducing their workload to the minimum possible.
6. **User Control**: All system control must be in the hands of users so that they can use it to meet their goals.

3. UsabilityZero

Here we present UsabilityZero, a web application designed to help undergraduate students: (i) understand the importance of usability and how it can affect user experience; (ii) distinguish some ways to measure usability; and (iii) recognize some criteria that promote good usability. The basic concept of our application is to promote to students the experience of dealing with a poorly designed interface and, later, with an interface designed with usability criteria in mind. After the interaction, the students should be able to compare how the application of usability criteria can impact users' performance to execute their tasks.

By using the application, students participate in two case studies. In the first case study, called Case Study 0 (CS0), their goals are to complete some tasks in an environment with intentionally reduced usability. In the second case study, Case Study 1 (CS1), the participating students have to finish the same tasks, but this time, they should be performed in an environment that applies some criteria that increase its usability. After each of the case studies, the students fill out a SUS satisfaction questionnaire and then receive a report with the respective measures of efficiency, effectiveness, and satisfaction resulting from their participation in that case study (see Fig. 1).

The context in which the students execute the case studies is the same – a web portal for access and participation in computer-related conferences. In both CS0 and CS1, the users find the same basic functionalities:

(i) A list of events and information about them.
(ii) An event registration form.
(iii) The possibility of issuing a certificate of participation.

However, the way the users interact with the system tends to be very different in both case studies due to usability differences. The tasks the student should perform on CS0

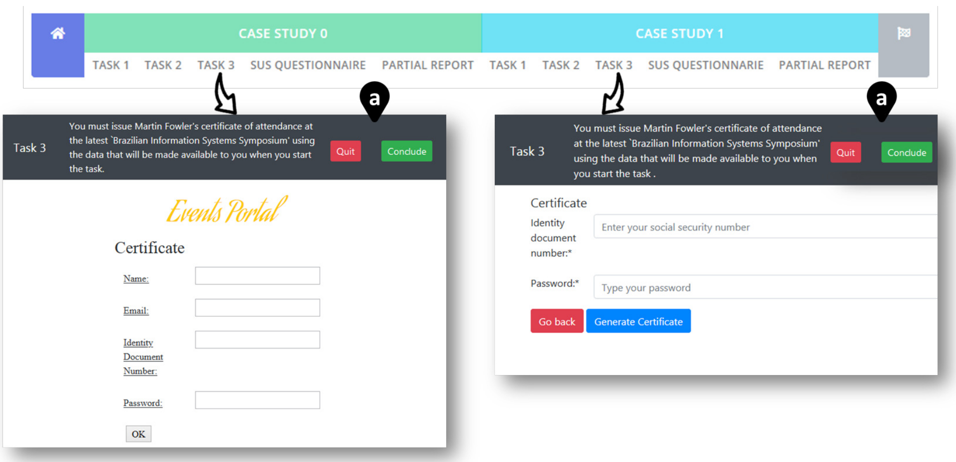


Fig. 1. UsabilityZero application flow.

and CS1 are the same since the goal is to highlight the importance of usability for the user experience. The requested tasks are the following:

1. "You plan to attend the next `Brazilian Symposium on Human Factors in Computing Systems'. Find out the registration fee for this event."
2. "You must register for the `Brazilian Software Quality Symposium' using the payment details that will be made available to you when you start the task."
3. "You must issue Martin Fowler's certificate of attendance at the latest `Brazilian Information Systems Symposium' using the data that will be made available to you when you start the task."

During the execution of the tasks, the screen displays a bar with directions on the upper part. Two buttons are on the right-hand side of the bar (*Quit* and *Conclude*) the user can press at any time during the execution of the tasks. The user should press the Conclude button when s/he understands that s/he has completed the task. Only then UsabilityZero confirms if the task was completed. As an example, Table 2 shows how usability criteria were applied for task #3 displayed in Fig. 1.

After completing the three tasks in both case studies, the student receives a final report (see Fig. 2). This report compares usability measures for CS0 (reduced usabil-

Table 2
Application of usability criteria for Task #3

Usability criteria	Violated in CS0	Met in CS1
Workload Reduction	Too many fields to fill in; In case of error, the screen is restarted with empty text fields.	Only two fields to fill in.
Error Handling	No default mask or formatting directions for text fields.	Text fields have formatting masks and hints to assist user.
User Control	No buttons to return or cancel the operation.	The user can give up at any time, cancelling the operation.
Consistency of interface elements	Required fields are underlined, unlike the widely used asterisk markup.	Required fields are marked by an asterisk, which is a widely used standard.

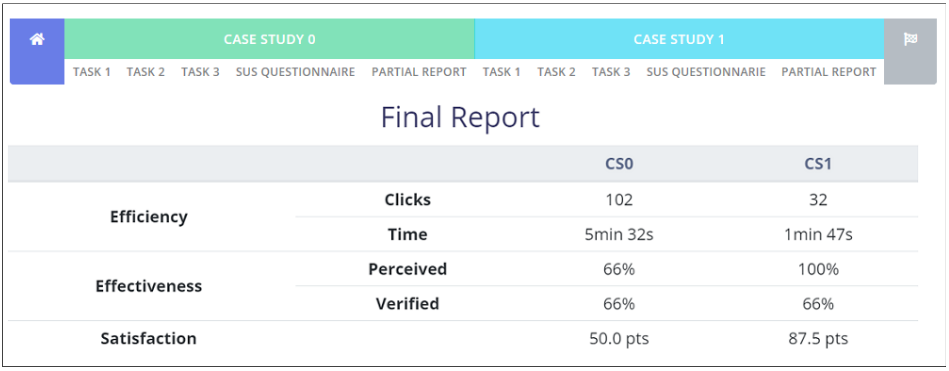


Fig. 2. UsabilityZero Final Report.

ity) and CS1 (with usability criteria applied). UsabilityZero considers the following measures:

- **Efficiency**: The application counts the number of clicks given and the time that the user has taken to complete each task in each case study, showing these values in the report.
- **Effectiveness**: Displays the percentage of tasks successfully completed by the user. For this measure, the application considers two aspects: (i) the verified effectiveness reflects the actual percentage of tasks completed verified automatically by the application; (ii) perceived effectiveness reflects the user's understanding of task completion.
- **Satisfaction**: Presents the score obtained from the SUS questionnaire.

4. Evaluation

In order to evaluate our application, we used the GQM (Goal-Question-Metric) approach (Basili *et al.*, 2014). The phases of planning, execution, and interpretation of the results are described below.

4.1. *Planning*

We had two goals with the evaluation. The first one was to verify whether UsabilityZero brought distinct experiences for the students in each case study. In other words, we wanted to know if CS0 provided a reduced usability experience when compared to CS1. We present the questions and the metrics defined for this goal in Table 3. Our

Table 3
Questions and metrics for Goal 1

G1: Analyze the application UsabilityZero for the purpose of assessing whether it allows for distinct experiences in each case study with respect to usability measures, from the viewpoint of students of Information Technology courses in the context of Usability Engineering.
Q1.1 Does CS1 bring greater efficiency than CS0?
M1.1.1 Time spent per user in each case study;
M1.1.2 Number of clicks per user in each case study;
Indicator Time and number of clicks is significantly less in CS1 than in CS0.
Q1.2 Does CS1 bring greater effectiveness than CS0?
M1.2.1 Rate of completed tasks per user in each case study;
Indicator Rate of completed tasks is significantly greater in CS1 than in CS0.
Q1.3 Does CS1 bring greater satisfaction than CS0?
M1.3.1 SUS score per user in each case study;
Indicator SUS score is significantly greater in CS1 than in CS0
Q1.4 Does CS1 bring good user satisfaction?
M1.4.1 Average score of users on SUS form in CS1;
Indicator Average score is above 70 points.

Table 4

Questions and metrics for Goal 2

G2: Analyze the application UsabilityZero for the purpose of assessing whether it allows you to learn about criteria and metrics of usability from the point of view of course students Information Technology in the context of Usability Engineering.
Q2.1 After using the application, can the user recognize the measures commonly used to evaluate the usability of a computing solution?
M2.1.1 Answers to the question "What aspects are commonly verified to evaluate the usability of a computing solution?"
Indicator The difference in recognition of *efficiency*, *effectiveness*, and *satisfaction* as usability measures before and after using UsabilityZero is considered statistically significant.
Q2.2 After using the application, can the user recognize how to measure the usability of a computing solution?
M2.2.1 Answers to "How can *efficiency* be measured?";
M2.2.2 Answers to "How can *effectiveness* be measured?";
M2.2.3 Answers to "How can *satisfaction* be measured?";
Indicator The difference in the recognition of how to measure *efficiency*, *effectiveness* and *satisfaction* before and after using UsabilityZero is considered statistically significant.
Q2.3 Can the user recognize usability criteria in their application experience?
M2.3.1 Score on the question "I was able to recognize several aspects that impact the ease of use of an application" per user;
M2.3.2 Answer to the question "Describe in detail 1 aspect that negatively impacted your user experience" per user;
Indicator It is considered that the user can recognize usability criteria if most (more than 50%) achieve values higher than 3 (on the 5-point Likert scale) in M2.3.1 and most cite some suitable usability criteria in M2.3.2.
Q2.4 Is the UsabilityZero application an interesting solution to learn about usability?
M2.4.1 Score on the question "I realized the importance of usability to the quality of a software product" per user;
M2.4.2 Score on the question "Application experience will contribute to my professional life performance" per user;
M2.4.3 Score on the question "I would recommend this app to my colleagues" per user;
Indicator Considered interesting if most users (over 50%) get values greater than 3 (on the 5-point Likert scale) in M2.4.1, M2.4.2 and M2.4.3.

second goal was to confirm whether the students had any learning on the theme after interacting with the application. Table 4 brings the questions and the metrics defined for this goal.

We used the data collected from participants' using UsabilityZero to answer the questions related to G1. The participants also filled out two forms, one before and another after their interaction, which helped us answer the questions related to G2.

4.2. *Execution*

The execution occurred following the steps illustrated in Fig. 3. First, the participants answered an "Informed Consent Form" and also some questions about their profile and previous knowledge in the area. Later, they answered some questions to assess their prior knowledge on the topics (pre-questionnaire). Then, each participant used Usabili-

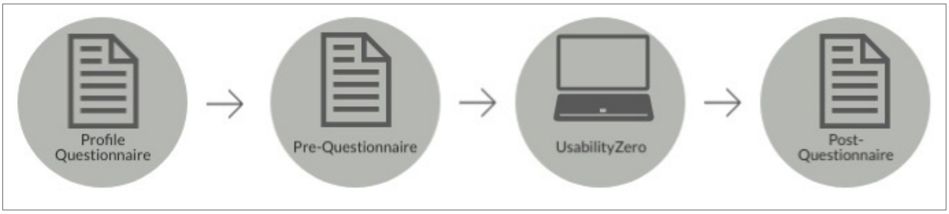


Fig. 3. Evaluation steps.

Table 5
Groups that evaluated the approach

Group	Period	Course (Major)	# Students	Context
C1	May, 2019	Software Engineering (Information Systems)	31	Topic not previously studied in class
C2	August, 2019	Usability Engineering (Computer Science)	11	Topic previously explained by the teacher
C3	November, 2019	Software Engineering (Information Systems)	22	Topic previously studied from print material

tyZero, performing the three tasks of each case study. Finally, they answered the post-questionnaire, which addressed the same questions as the pre-questionnaire together with some questions about their experience using the tool.

We conducted the assessment in 3 distinct classes as shown in Table 5.

Five students from group C1 declared they had had some classes on usability before, another had some previous contact with the theme at work, and two others had studied it as a self-interest. The tool remained stable during all three evaluation sessions and no failures were reported.

4.3. *Interpretation of the Results*

This section presents the results obtained for each question planned in the evaluation.

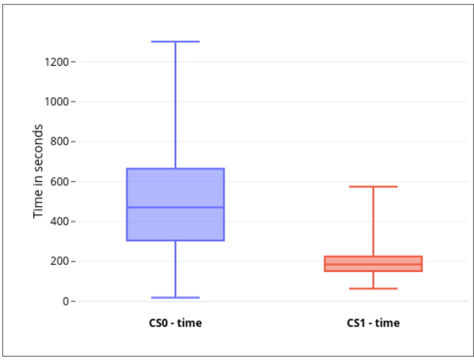
4.3.1. *G1 – Evaluate if UsabilityZero Allows for Different Experiences in Each Case Study Regarding Usability Measures*

Question Q1.1 investigated efficiency differences in both of the case studies brought by the application. To verify the performance efficiency of the participants, we considered both the time to complete the tasks and the number of clicks (Figures 4a and 4b). Our data point to a 62.2% decrease in average time (from 520.5 seconds in CS0 to 196.6 seconds in CS1) and a 61.5% decrease in the average number of clicks (from 102.5 clicks in CS0 to 39.3 clicks in CS1). We used the Wilcoxon Signed-Rank Test to verify if the differences for time and clicks were significant. Analyzing the time difference, we got $z = -6.7611$ and $p\text{-}value < .00001$. For the difference in the number of clicks, we got $z = -6.7708$ and $p\text{-}value < .00001$. Considering the observed data, we can conclude that their performance in CS1 was more efficient than in CS0.

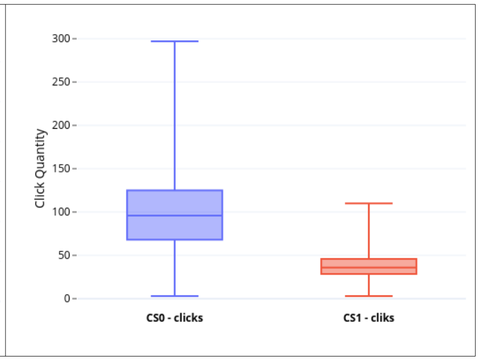
When assessing the effectiveness difference between both of the case studies with question Q1.2 (Fig. 4c), we noted an increase of 92.9% in the average number of completed tasks (from 38.7 tasks in CS0 to 74.7 tasks in CS1). That is a significant difference, with $z = -5.9052$ and $p\text{-}value < .00001$. Thus, we can consider that, for the observed sample, the participants were more effective in completing their tasks in CS1 than they were in CS0.

The difference between the satisfaction provided by the two case studies, analyzed by questions Q1.3 and Q1.4, was also quite marked (Fig. 4d). While the average score of students on the SUS scale was 21.7 points in CS0, it was 81.9 points in CS1 (277.3% increase), approaching excellent satisfaction (Bangor *et al.*, 2008). The Wilcoxon Signed-Rank Test confirmed that the difference in satisfaction was significant, with the values of $z = -6.759$ and $p\text{-}value < .00001$. So, we can consider that the experience with CS1 was more satisfactory than with CS0.

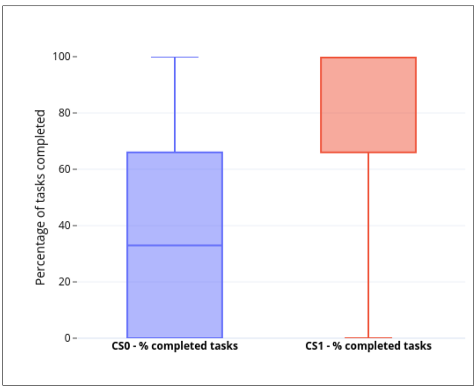
Based on the results above, we can conclude that Case Study 1 presents the user with higher usability compared to Case Study 0.



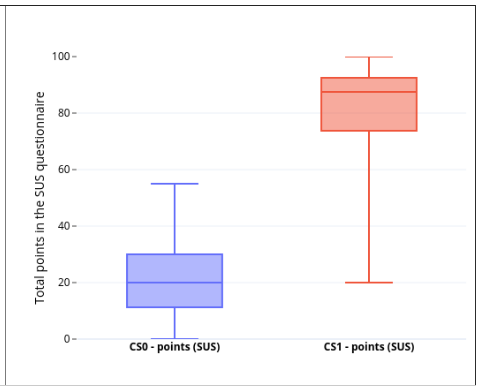
(a) Efficiency – time



(b) Efficiency – clicks



(c) Effectiveness



(d) Satisfaction

Fig. 4. Usability measurements obtained in CS0 and CS1 evaluation.

4.3.2. *G2 – Evaluate if UsabilityZero Allows Students to Learn about Usability*

We used the answers to the questionnaires (pre and post) to estimate if goal G2 was achieved. Since the participants had to fill out the forms immediately before and after they used UsabilityZero, we could evaluate if they had some learning with the use of our tool. Three of the questions intended to evaluate whether the students could recognize the measures commonly used to estimate the usability of a user interface (Q2.1). They were similar questions that aimed at *efficiency*, *effectiveness,* and *satisfaction*, respectively. The participants had to choose the right answers from a set of eight different alternatives, among which were the options "*I don't know.*" and "*Other.*" More than one alternative could be checked as correct.

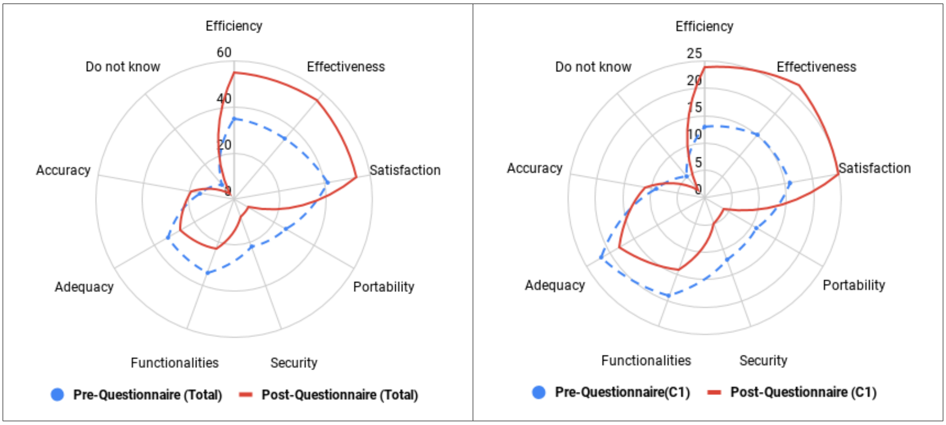
Table 6 presents the $p\text{-}values$ obtained from the McNemar Test for the three usability measures in each of the evaluated classes. A small $p\text{-}values$ (typically ≤ 0.05) indicates strong evidence against the null hypothesis, and it should be rejected. Our null hypothesis is that UsabilityZero does not help recognize usability measures. These values show that, after using UsabilityZero, more students came to recognize efficiency, effectiveness, and satisfaction as usability measures (Fig. 5). However, we highlight that:

- For group C2, the tool did not significantly affect the recognition of usability measures. This is justified by the fact that the group had had a class on the subject before and, as shown in the graph in Fig. 5(c), the class was sufficient to learn the measurements.
- For class C3, the tool did not significantly affect the recognition of the satisfaction measure. In this case, reading material or prior knowledge was sufficient for students to understand the point.
- The experience was not enough to show students that other measures do not apply to the topic (although the application does not have that goal), as we can see from the graphs in Fig. 5. We believe that further discussion between the teacher and the students may help eliminate any confusion.

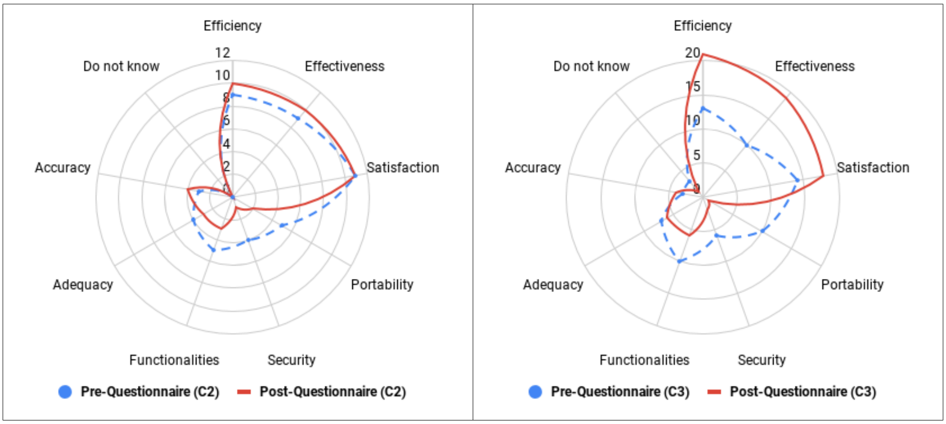
By presenting the reports with the usability measures of the students' performance, we hoped that they could understand how those measures are obtained. The data collected from the questionnaires to answer Q2.2 show an increase in the perception on how to measure *efficiency* (from 56.2% to 70.3%), *effectiveness* (from 40.6% to 60.9%) and *satisfaction* (from 60.9% to 71.8%), see Fig. 6. This variation was not significant when we applied the McNemar Test for *efficiency* ($p\text{-}value = 0.1374$) and *satisfaction* ($p\text{-}value = 0.1904$). However, the test pointed to a significant effect on learning how to measure *effectiveness* ($p\text{-}value = 0.0088$).

Table 6
Statistical test result for question Q2.1

	Efficiency(p-value)	Effectiveness(p-value)	Satisfaction(p-value)
C1	0.00982	0.0015	0.01586
C2	1	1	0
C3	0.01333	0.01586	0.28884
Total	0.00011	0.00002	0.00591



(a) Considering all participants (b) Considering participants in class #C1



(c) Considering participants in class #C2 (d) Considering participants in class #C3

Fig. 5. Recognition of usability measures before and after UsabilityZero.

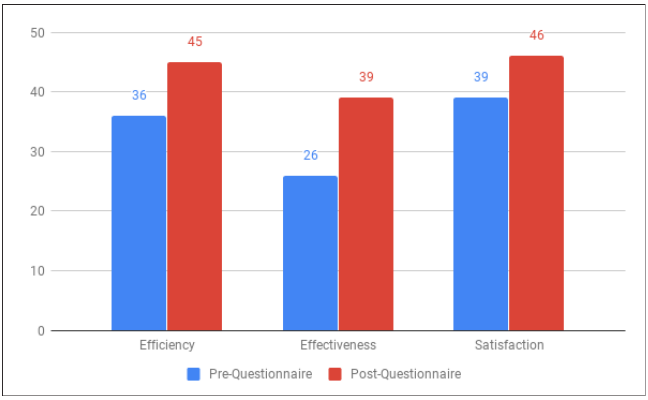
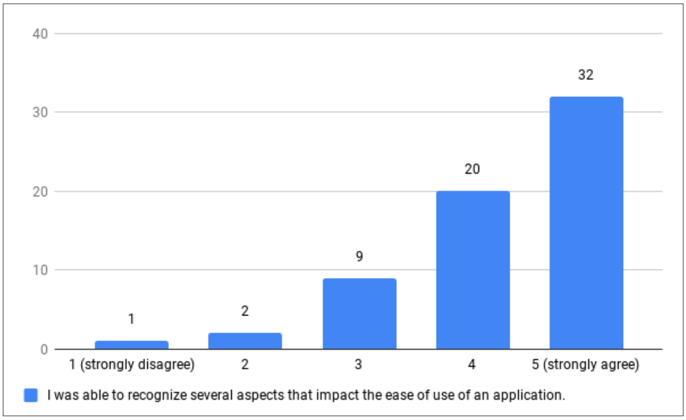


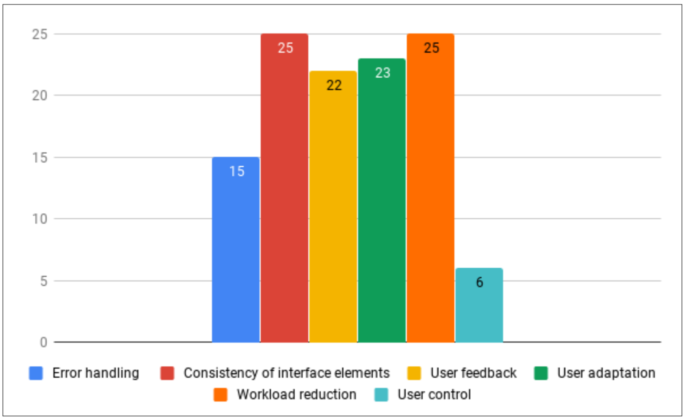
Fig. 6. Students' understanding of how to get usability measurements.

Most of the participant students (81.2%) confirmed on the post-questionnaire that they could "recognize several aspects that impact the ease of use of an application (see Fig. 7a). They also described some aspects that harmed their experience. Since the participants described those aspects in an open question, we analyzed each response and mapped them with one or more of those criteria UsabilityZero highlights (section 2. We could not establish a relationship of 4 out of the 64 answers with any of the usability criteria. Over 93% of students have recognized at least one usability criterion in the application. We believe UsabilityZero can be a useful tool to support teaching this topic because the teacher can bring many of these elements to discuss with the students later in class. Fig. 7b quantifies the usability criteria the students indicated.

Finally, question Q2.4 sought to learn how interesting the experience with the application was for students. The questions in the post-questionnaire that addressed Q2.4 all used a 5-point Likert scale from1 (*strongly disagree*) to 5 (*strongly agree*)". 59 students (92.1%) replied 4 or 5 to the statement "I realized the importance of usability



(a) Students' perception if the tool helped to recognize aspects that facilitate usability



(b) Criteria identified by participants

Fig. 7. Recognition of usability aspects.

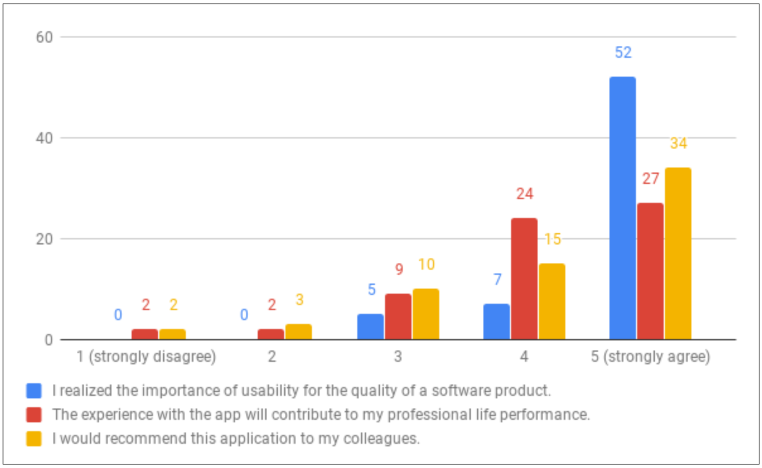


Fig. 8. Results about student interest regarding UsabilityZero.

for the quality of a software product", 51 (79.6%) to the statement "The experience with the app will contribute to my professional life performance", and 49 (76.5%) to the statement "I would recommend this application to my colleagues." These values are relevant to confirm that students who participated in this evaluation understood the purpose of the application and the importance that following some usability criteria has to improve human-computer interaction. The detailed result can be observed in Fig. 8.

5. Conclusions

In a scenario with few computational solutions specifically designed to support usability teaching (Benitti and Sommariva, 2012; Lima and Benitti, 2019), UsabilityZero contributes by providing a different experience to HCI students. The evaluation of the application in three classes has shown that:

- UsabilityZero provides different usability experiences in each case study, allowing students to understand how usability can impact their performance when executing a task.
- The tool allows the student to identify usability measures – efficiency, effectiveness, and satisfaction. This result was observed when students had not previously studied the subject.
- UsabilityZero provided students with an understanding of how to measure the effectiveness of an application. In the evaluated sample, learning how to estimate efficiency and satisfaction was not significant.
- UsabilityZero allowed users to recognize some aspects that impact usability.
- The vast majority of the 64 students who took part in the evaluation of UsabilityZero claimed that it is an interesting application to learn about usability.

We recognize some threats to the presented results that leave us with some questions to be answered in future work: (i) Does the interface aesthetics have such importance as to change the final results? (ii) Since CS0 and CS1 have the same functionalities, could the students have learned from the first case study leading them to better results in the second one? (iii) Would a larger sample have more significant results? (iv) Would the results be confirmed in a controlled environment with a control group?

To this point, UsabilityZero has proved to be a stable, workable solution for teachers and students to use.

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