Helping psychology students improve their statistics performance: A test of the Exo-St@ts web-based training environment

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1. Introduction

1.1 Web-based learning environments

To improve students' interest and performance in university courses, a number of web-based environments have been developed. A web-based training environment, or just-in-time training, consists of modularized training courses, available anytime and anywhere over the Internet. It offers students the possibility of learning about a subject or skill using specific programs or web-pages instead of books or personal teaching.

Web-based training environments deliver performance feedback in many ways; for example, computerized quizzes with multiple-choice questions provide automated answer analysis and individual feedback based on the student's own performance (e.g., Krause Stark, & Mandl, 2009[1]; Maki & Maki, 2001[2]). Feedback is considered to be an important construct in many theories of learning, performance, and instruction. It provides learners with information that allows them to verify the correctness of the actual response or solution they gave and to evaluate their performance level (e.g., DeShon, Kozlowski, Schmidt, Milner, & Wiechmann, 2004 [3]). Performance feedback has been widely demonstrated to be one of the most effective ways of improving learning and task performance (e.g. Kluger & DeNisi, 1996 [4]). Thus, by delivering useful feedback, computerized quizzes are a good way for instructors to help students in their learning and understanding of the topics introduced in the classroom (e.g. Brothen & Wambach, 2001 [5]).

1.2 The statistics issue

Several web-based training environments have recently been used to deliver feedback in statistics courses (e.g., DeVaney, 2010 [6]; González, Jover, Cobo, & Muňoz, 2010 [7]; Hsu, Wang & Chiu, 2009 [8]; Krause, Stark, & Mandl, 2009 [1]). Statistics is an important part of the psychology degree program. As a great amount of precise knowledge is involved in this course, it can be tested by multiple-choice quizzes in web-based environments. Moreover, many students in psychological sciences have difficulty understanding and applying statistical concepts and procedures (Broers & Imbos, 2005 [9]), lack motivation about statistical issues (Wilks, 2006 [10]), and suffer from statistics anxiety (Onwuegbuzie, 2004 [11]). These problems depend partly on the students' academic background (Onwuegbuzie & Wilson, 2004 [12]), notably basic math skills, previous knowledge of statistics, number of math courses taken in high school (Roberts & Saxe, 1982 [13]), as well as other individual variables such as perceived math competence and intellectual capacities (Onwuegbuzie, 2000a [14). For these students, statistics courses can thus be a negative experience (Onwuegbuzie & Wilson, 2004 [12]), leading to a lack of motivation and a tendency to procrastinate and put off exam preparation (Onwuegbuzie, 2004 [11]). Based on these findings, it could be interesting to use web-based training environments to complement statistics teaching at university using computerized quizzes.

1.3 Exo-St@ts

A web-based training environment – *Exo-St@ts* – has been developed at the European University of Brittany (Rennes 2) to allow psychology students to train in statistics, offering them a large number of options to prepare for their examination.

This entirely computerized environment is accessible online from a web interface, and consists of a range of statistics exercises. It is password-protected and a server keeps a log of students' connections to the site. The homepage (see Figure 1) presents the whole set of exercises the students have to carry out, organized in 15 teaching units (e.g. "Discriminate the levels of measurement", "Identify measures of central tendency from a given graph", "Compute a linear correlation coefficient"), each one containing a set of twenty numbered exercises. In total, there are 300 exercises corresponding to different parts of the first year statistics course.

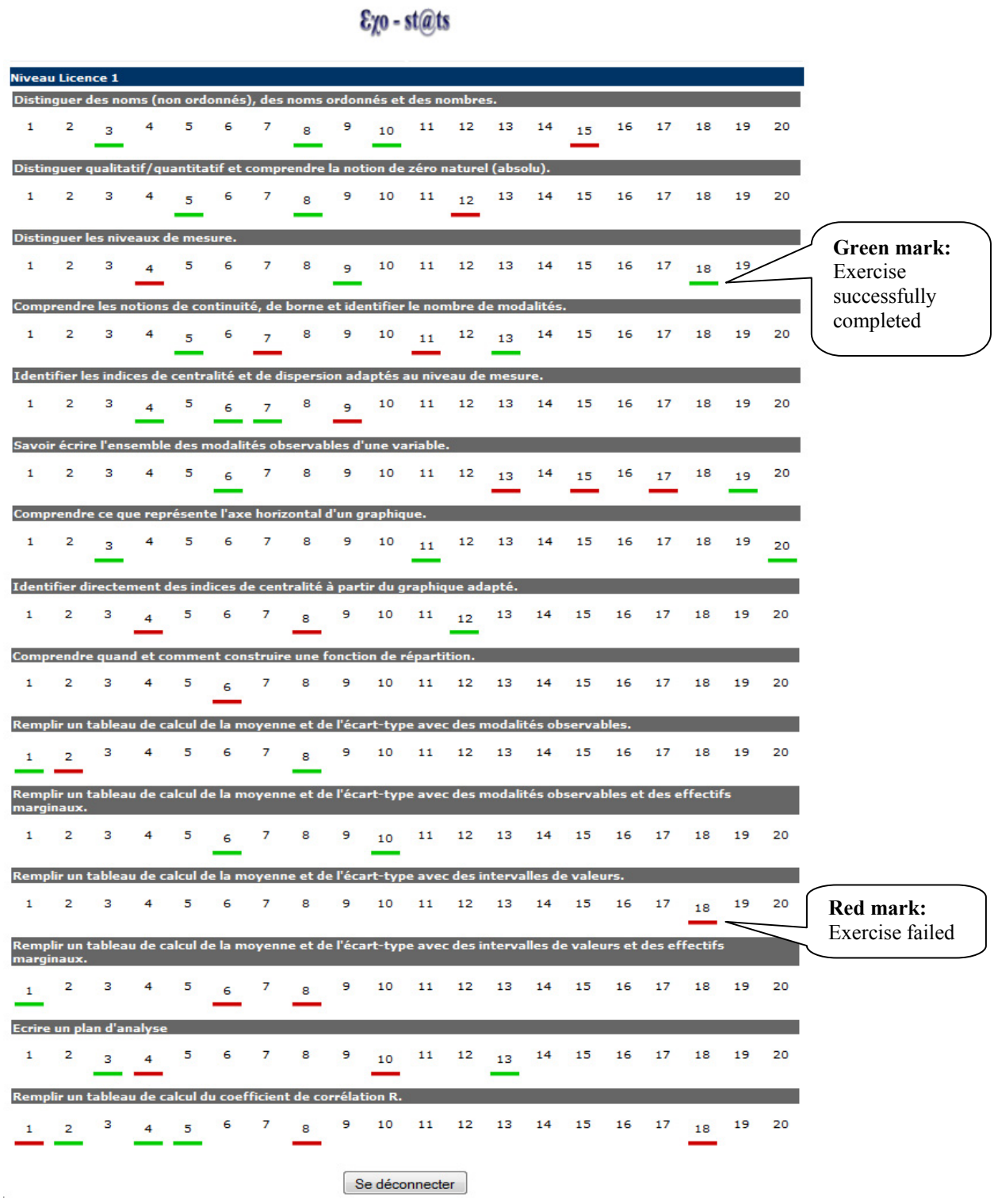

Figure 1. Set of exercises in *Exo-St@ts*, with the corresponding colored feedback

Students can access each exercise by clicking on the item number. They then answer directly and receive immediate feedback telling them whether their answer is correct or not and providing the correct answer if necessary (see Figure 2).

Figure 2. Example of an exercise on *Exo-St@ts* and its corresponding positive feedback.

Once an exercise has been completed, the student can go back to the home page and see which exercises have already been attempted. The exercises that have been done correctly are marked in green, and those that were incorrect are marked in red, indicating the overall level of achievement (see Figure 1).
Students can do the exercises in any order, they can try the same exercise several times if they get it wrong, and can log off whenever they like. Their level of achievement and the items completed are recorded and appear as such each time the students log on.

In order to test the efficiency of the *Exo-St@ts* web-based training environment, a study was conducted among first-year psychology students who were given the possibility of using it during the first semester. This research could not take the form of an experimental study as it was carried out directly with students during their exam preparation; the aim of the study was thus to examine how students used the environment and whether or not it was beneficial in terms of performance. Because the students were not randomly assigned to different conditions, we used a non-equivalent control group design (quasi-experimental) and compared students who did not use *Exo-St@ts* (control condition) with those who did (experimental condition).

We hypothesized that students who used *Exo-St@ts* would perform better on the exam than those who did not. We also expected that the more students used *Exo-St@ts*, the higher their grades would be.

2. Method

2.1 Participants

The statistics exam was taken by 518 first-year psychology students, aged 17 to 38 (M = 19.26; SD = 1.68). The basic math skills test was taken by 79% (N = 407) of the students. Only these students were included in the study, as this was one of the control variables. During the eight weeks prior to the exam, 52% of these students (N = 212) attempted at least one exercise on *Exo-St@ts*.

2.2 Procedure

The training program was entirely available online, and was accessible eight weeks before the first semester exam. Students were informed by e-mail that they could use the web-based training environment to prepare their statistics examination through a series of online exercises. A hyper-link was provided in the e-mail message allowing them to access the system directly using a single mouse click; the same e-mail also explained the procedure for accessing *Exo-St@ts* directly without having to retrieve the hyper-link. When students registered to use the web-based environment, they were asked to read a consent form and to accept the conditions of use. Students who refused the conditions had the possibility of working with the statistics exercise booklet on which all the online quizzes were based.

2.3 Measures

2.3.1 Basic Math Skills

Basic math skills were measured using a 20-item test taken by all the students during the first statistics tutorial, and which consisted of math questions of increasing difficulty. One point was given for a correct answer and zero for an incorrect answer, giving a maximum score of 20.

2.3.2 Use of *Exo-St@ts*

Students were divided into two groups: Exo-St@ts users and non-users. A student was considered as a user if he/she tried at least one exercise from the program. Two other variables were measured: the total number of exercises attempted, and the number that were correct (learning performance measures, ranging from 0 to 300). In addition, the date of the first connection to the website was recorded as a behavioral measure of procrastination.

2.3.3 Exam performance

Performance was measured by the score obtained in the final statistics exam (exam performance measure, ranging from 0 to 50 points – one point per correct answer). There were three sections in the final exam, each corresponding to a unit of the statistics course and thus to different parts of the web-based training program. The first section involved describing different variables based on the description of an experiment, corresponding to the first six topics of *Exo-St@ts*. The second section involved calculating Pearson's linear correlation coefficient *r*, corresponding to the last topic in *Exo-St@ts*. The third section involved constructing various frequency tables and graphs; this topic was presented least in *Exo-St@ts*. In order to avoid too much variation in the evaluation, the exam was corrected by several teachers using a standardized assessment grid which provided specific recommendations for all the criteria to be applied to each of the 50 items.

3. Results

3.1 Impact of *Exo-St@ts* on exam performance

Table 1 shows the means and standard deviations for each group. We hypothesized that students who used *Exo-St@ts* would perform better in the exam than those who did not. Data seem to confirm this, as the average score of users was 15 points higher than that of non-users.

Table 1 Exam performance: Means and Standard Deviations (range: 0 to 50).

Use of *Exo-St@ts*	M	SD	N
Non-Users	14.90	11.23	195 (48%)
Users	30.54	13.38	212 (52%)
Total	23.05	14.65	407

To test the hypothesis further, a regression analysis was conducted to assess whether the use of *Exo-St@ts* predicted final exam results. Basic math skills were controlled as a covariate in this analysis.
The overall model was significant, F (2, 404) = 156.998, $p < .001$, $R^2 = .435$. The results revealed a main effect of the use of *Exo-St@ts* on success in the final exam, $\beta = .46$, $p < .001$, students who used the training environment achieving better exam performance than those who did not. Secondly, they indicated a strong influence of basic math skills, $\beta = .40$, $p < .001$, students with better basic math skills obtaining higher marks.

3.2 Relationship between variables

We also examined variables within *Exo-St@ts* users. Table 2 shows the correlations between basic math skills, date of first connection, number of exercises attempted, number of exercises completed successfully, and examination performance. Analysis indicates that the students who were better at mathematics studied more and earlier and did better in the final exam. This suggests that students with poor basic math skills tended to use *Exo-St@ts* less than the

others and started to study later in the semester. Overall, there was a negative correlation between the date of first connection and exam performance: the earlier students started to use the program, the better their performance. Additionally, the number of *Exo-St@ts* exercises completed was strongly and positively correlated with examination performance, indicating that the more students used the program, the higher their marks.

Table 2 Summary of, Means, Standard Deviations and Intercorrelations for Basic Math Skills, Date of connection, Number of Exercises Attempted, Number of Exercises completed successfully, and Exam Performance.

Measure	M	SD	1	2	3	4	5
1. Math	12.06	3.42					
2. Date of connection	30.57	21.27	-.137*				
3. Exercises attempted	115.65	102.66	.142*	-.224**			
4.Exercises completed correctly	69.12	63.82	.216**	-.217**	.951***		
5. Exam performance	30.54	13.38	.460**	-.221**	.338**	.418**	

Note. * p < .05, ** p < .01, *** p < .001, N = 212

4. Discussion

4.1 Outcome

The aim of this study was to test the efficacy of the *Exo-St@ts* web-based training program, which has been developed to help psychology students learn statistics. The main result is that students who used *Exo-St@ts* performed significantly better than those who did not, indicating that this web-based training environment can be beneficial for students studying statistics.

A further result of this experiment is that there were differences in the way students used *Exo-St@ts*. For example, some started to connect very early, others just before the exam; some did a lot of exercises, others very few. Thus, even though the environment was widely used (41% of the students who took the exam used it at least once), there was considerable variability between the users, due mainly to the complete autonomy in which they worked. Following this observation and our exploratory data, it is important to investigate how this web-based training environment can be improved so that as many students as possible can use it effectively.

Firstly, it appears that efforts are needed to encourage as many first-year psychology students as possible to use the program to prepare their exam. Secondly, differences in the use of the environment must be taken into account to understand the conditions under which it is used most efficiently. In other words, students should be encouraged to log in as early as possible and to attempt as many exercises as possible. This should give them a greater chance of being well-prepared for the examination.

To achieve these goals, it is particularly important to consider how traditional classroom teaching can be linked to this new online environment to create a blended learning approach.

4.2 Outlook

In our study, students only used *Exo-St@ts* on their own computers at the university or at home and could not use it during the statistics classes. This can clearly lead to behavioral issues such as procrastination or even to non-use by many low-achievers or anxious students. Furthermore, it can be assumed that some students used it without real effectiveness and with no real benefit in terms of understanding and performance. For example, Brothen and Wambach (2001) [5] showed that students who used a "quiz-to-learn strategy", whereby they did a large number of quizzes in the hope of improving without any preparatory work using traditional materials, were less successful than those who succeeded in combining the two types of material. Students should therefore be helped to combine classroom materials with the use of a web-based environment where they have to work on their own. Our study demonstrates that students need to be supported in their use of this kind of environment, as total autonomy leads many of them to give up statistics or to misuse the online training environment. As it is difficult to use *Exo-St@ts* directly in tutorials, tools such as electronic voting systems or "clickers" can be used to help combine traditional classroom methods with computerized quizzes. Research shows that these systems enhance students' participation during class (Graham, Tripp, Seawright & Joeckel, 2007 [15]) and that their anonymity and immediate feedback allow students to evaluate their own performance during class (Lantz, 2010 [16]). Introducing some *Exo-St@ts* exercises in these voting systems could be one way of combining traditional teaching methods with the web-based training environment, and may encourage students to

continue to work on the topic alone. The use of "clickers" in the classroom can also facilitate the presentation of pre-established structures which students can use to organize their learning strategies (Lantz, 2010 [16]), and help them organize their individual work in the web-based environment. Devices like this can thus be envisaged to complement the teaching of difficult courses such as statistics in human sciences, particularly psychology, and guide the use of quizzes.

4.3 Limitations and conclusion

Overall, our results must be interpreted cautiously because we have to consider the possibility of an auto-selection bias; it is reasonable to assume that students with good basic math skills were less frightened by statistics and therefore tended to use the system more than those with poor basic skills (see correlations Table 2). Students also had the possibility of using a statistics exercise booklet to prepare for their exam, and it is conceivable that students who used *Exo-St@ts* also used this exercise booklet. On the whole, the use of *Exo-St@ts* may be just one of many variables accounting for differences in examination performance (basic math skills, motivation, amount of time spent working, etc.).

These limitations need to be taken into account in future research examining in greater depth the impact of this web-based training environment on students' academic achievement.

However, although other variables can contribute to the success or failure of the web-based environment (i.e. math-skilled students tend to use *Exo-St@ts* more and to log on sooner to do exercises), it is clear that this tool can play a role in exam success. This is encouraging for the development of Exo-St@ts and should be the basis for further research.

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