Adv Mobile Learn Educ Res, 2023, 3(2): 825-828
DOI: 10.25082/AMLER.2023.02.010

RESEARCH ARTICLE

Creating simulation applets to teach statistics

Dimitrios Kallivokas

Department of Business Administration, University of West Attica, Athens, Greece

Correspondence to: Dimitrios Kallivokas, Department of Business Administration, University of West Attica, Athens, Greece; Email: dkalliv@uniwa.gr

Received: June 2, 2023;
Accepted: August 2, 2023;
Published: September 6, 2023.

Citation: Kallivokas, D. (2023). Creating simulation applets to teach statistics. *Advances in Mobile Learning Educational Research*, 3(2), 825-828. https://doi.org/10.25082/AMLER.2023.02.010

Abstract: The purpose of this study is whether the use of software for simulating concepts of statistics and probability theory during a semester introductory statistics course ensured greater success in the final exam of the course for students who used it, compared to students who used general statistical software. The simulation software used was created for this purpose based on the average level of understanding of the students who attended the course. The students who attended the course were divided into two groups in a way that ensured that the two groups had proportionally about the same level of statistical knowledge, mathematical background, and about the same number of students in terms of origin and gender. One group used simulation software throughout the semester, while the other used general statistical software. The simulation software used in this survey was created for this purpose based on the average level of understanding of the students who attended the course. At the end of the semester after the final exam, various factors were considered and students' final exam performance (success rates), were compared based on these factors. It appeared that success in the final exam when it comes to similar populations as the two groups of students who attended the course has a strong dependence on the factor of using simulation software.

Keywords: statistics education, teaching statistics using ICT, teaching statistics with applets, simulation software

1 Introduction

It is accepted that the use of appropriate information and communication technologies (ICT) can assist in the understanding of concepts, assist in learning and create conditions for the development of literacy (Abid et al., 2022; Anastasiades & Zaranis, 2016; Ghavifekr et al., 2014).

In teaching of Statistics & Probability Theory courses, the teacher-centered model is often used (Batanero et al., 2011). However this model is not suitable in classes where students have different mathematical backgrounds and level of knowledge.

Also general software such as spreadsheets or general statistical software where often used in the teaching of these courses (Tucker et al., 2023; San et al., 2019). These software however are standardized and requires learning of their interface and functions. Furthermore these software packages, execute operations and commands giving outputs, without many times to visualize the results and without the possibility of experiments that go deeper into the conclusions, while in many of them there is no parametricity, with the result that the students with simple actions cannot immediately see changes in the results if the data changes, but the commands need to be re-executed with the new data and thus making it difficult to understand the concepts.

In research it is reported that the use of small applications, which visualize the results and can be easily executed in various operating environments and devices such as computers, tablets (Volk et al., 2017) and smartphones (Kalogiannakis & Papadakis, 2017), are likely to facilitate learning and broaden students' engagement with data which helps to develop learning teaching (Ziatdinov & Valles, 2022).

The problem with these applets while they can work as learning tools and concept simulation models, is that they are standardized and they don't always focus on the points that really need to be drilled into. Each class of students as a whole has different needs (Aluvalu et al., 2017) and has understood basic concepts in a different way and to a different degree. Especially in classes of students of Administration and Economics where the mathematical background is different and where some students have not previously been taught statistical concepts, it is necessary to develop suitable software applications, which do not have special learning requirements for its functions and which simulates or visualizes the statistical concepts, taking into account the knowledge of the students of the specific class.

Suitable environments and platforms can be used to develop such simulation applications. In the environment of spreadsheets (Tsai & Wardell, 2006) with macros and programming tools, applications can be developed which act as simulation models. Software applications that visualize data and software applications that simulate statistics and probability theory concepts, can be developed in mathematics software platforms such as geogebra (Morphett et al., 2015) or in multimedia environments such as those of multimedia authoring tools (Hohenwarter & Preiner, 2007).

The applet development environments mentioned are not particularly demanding and an educator can become familiar with them without much difficulty.

2 Materials and methods

The research was done in an introductory course in Statistics in a department of the School of Administration and Economics of a tertiary institution. 96 students participated in the survey. At the beginning of the semester, a test (quiz) was given to the students to check their mathematical level, the understanding of fundamental concepts to master and deepen statistical concepts, such as percentages, fractions and graphs, and based on the answers the students were placed in the two groups. In the grouping, an attempt was made to have people with similar deficiencies in the same group. An effort was also made to ensure that the two groups were identical in terms of their composition of people of the same gender, similar level of knowledge, mathematical background and origin, and that their composition was not far from a real class of students in administrative-economic schools, so that finally the results of the experiment can be generalized.

Then, taking into account the students' level of understanding of concepts according to the test results, small applications were developed to simulate statistical and probability theory concepts using multimedia authoring tools, Geogebra Space and spreadsheets. These applications covered the entire material of the taught course.

Only the students participating in the experimental group had access to the software models created for the educational intervention. These people depending on their knowledge could use this software more or less since they were first divided into small groups based on the criterion that there is always someone with a better level in each small group. The two groups were assessed on the same concepts and the same test in the final exam of the course.

The final exam of the course was common to both groups and all students were given the same exam questions. The students who participated in the examination were a total of 93 from both groups, 46 from the experimental group and 47 from the control group. After the final exam of the course and since the result of the final exam was recorded for each student of both groups, it was examined whether the performance in the final exam for each student depends on his participation in a group (experimental and control). It was also examined whether the performance in the final exam for each student depends on the gender of the student regardless of group participation.

The hypothesis tested was whether success in the final exam depends on the use of the simulation software used throughout the semester.

For this purpose, the categorical variable 'performance' (achievement) was created, which received the values 'bad', 'average', 'good', depending on the results in the final exam for each student. The categorical variable 'group' had a value of 1 if the student participated throughout the semester in the experimental group that used the simulation software and 2 if he belonged to the control group that did not use the simulation software. A chi-square test of independence was performed (McHugh, 2013). The degrees of freedom are $df=(3-1)\times(2-1)=2>1$ so there is no need for Continuity Correction (Haber, 1982) which proposed by Yates (1934).

Table 1 Exam performance with group cross tabulation

Exam Performance		Group		Total
		Experimental Group	Classical Group	
Bad	Count	7	17	24
	Expected Count	11.9	12.1	24.0
Average	Count	18	19	37
	Expected Count	18.3	18.7	37.0
Good	Count	21	11	32
	Expected Count	15.8	16.2	32.0
Total	Count	46	47	93
	Expected Count	46.0	47.0	93.0

Table 2 Chi-square test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.309[a]	2	0.026
LikelihoodRatio	7.491	2	0.024
Linear-by-Linear Association	7.216	1	0.007
N of valid Cases	93		

Note: [a] 0 cells (,0%) have expected count less than 5. The minimum expected count is 11.10.

The hypothesis whether student achievement and student gender are dependent variables were also tested. The categorical variable 'gender' took values 1 (male) and 2 (female). A chi-square test of independence was performed. The degrees of freedom are df=(3-1)×(2-1)=2>1 so no Continuity Correction is needed.

Table 3 Exam performance with gender cross tabulation

Exam Performance		Gender		Total
		Male	Female	
Bad	Count	11	13	24
	Expected Count	11.1	12.9	24.0
Average	Count	17	20	37
	Expected Count	17.1	19.9	37.0
Good	Count	15	17	32
	Expected Count	14.8	17.2	32.0
Total	Count	43	50	93
	Expected Count	43.0	50.0	93.0

Table 4 Chi-square test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	0.008[a]	2	0.996
LikelihoodRatio	0.008	2	0.996
Linear-by-Linear Association	0.007	1	0.936
N of valid Cases	93		

Note: [a] 0 cells (,0%) have expected count less than 5. The minimum expected count is 11.10.

This hypothesis test shows that the variables: performance in the final exam and gender of the student are independent.

3 Discussion and conclusion

From the hypothesis tests carried out it is concluded that the success in the final exam of the course and the use of simulation software during the semester are dependent variables and that finally the use of simulation software positively affected the success in the final exam of the course. This conclusion is strengthened by the fact that both research groups had an identical composition at the beginning of the semester in terms of prior knowledge, mathematical background, gender ratio and origin. The main conclusion is that the development of appropriate applications that visualize statistic and probability theory concepts and provide possibilities for experimentation, ultimately contribute to students' understanding of statistical concepts and help to develop statistical thinking and improve statistical literacy. Moreover, similar surveys to date have shown that simulation software promote statistical literacy (Schneiter, 2008; Doi et al., 2016).

Conflicts of interest

The author declares that they have no conflict of interest.

References

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. Sustainable Operations and Computers, 3, 275-285. https://doi.org/10.1016/j.susoc.2022.05.004

Aluvalu, R. K., Kulkarni, V., & Asif, M. (2017). Handling classrooms with students having heterogeneous learning abilities. Journal of Engineering Education Transformations, 30(3), 229-234. https://doi.org/10.16920/jeet/2017/v31i2/119557

Anastasiades, P., & Zaranis, N. (2016). Research on e-Learning and ICT in Education. Springer, ISBN: 978-3-319-34125-5. https://doi.org/10.1007/978-3-319-34127-9

Batanero, C., Burrill, G., & Reading, C. (2011). Overview: challenges for teaching statistics in school mathematics and preparing mathematics teachers. Teaching statistics in school mathematics-challenges for teaching and teacher education: a joint ICMI/IASE study, 407-418.

Potter, G., Wong, J., Alcaraz, I., & Chi, P. (2016). Web application teaching tools for statistics using R and shiny. Technology Innovations in Statistics Education, 9(1). https://doi.org/10.5070/T591027492

Ghavifekr, S., & Rosdy, W. A. W. (2015). Teaching and learning with technology: Effectiveness of ICT integration in schools. International journal of research in education and science, 1(2), 175-191.

Haber, M. (1982). The continuity correction and statistical testing. International Statistical Review/Revue Internationale de Statistique, 50(2), 135-144. https://doi.org/10.2307/1402597

Hohenwarter, M., & Preiner, J. (2007). Creating mathlets with open source tools. The Journal of Online Mathematics and Its Applications, 7, 1-29.

McHugh, M. L. (2013). The chi-square test of independence. Biochemia medica, 23(2), 143-149. https://doi.org/10.11613/bm.2013.018

San, S. N., Myint, M. Y., & Aung, C. (2019). Teaching data Analysis using SPSS. International Journal of Trend in Scientific Research and Development, 3(5).

Kalogiannakis, M., & Papadakis, S. (2017). Combining mobile technologies in environmental education: a Greek case study. International Journal of Mobile Learning and Organisation, 11(2), 108-130. https://doi.org/10.1504/IJMLO.2017.084272

Morphett, A., Gunn, S., & Maillardet, R. (2015, November). Developing interactive applets with GeoGebra: processes, technologies. In Elephant Delta: 10th Southern Hemisphere Conference on the Teaching and Learning of Undergraduate Mathematics and Statistics (pp. 110-132).

Schneiter, K. (2008). Two Applets for Teaching Hypothesis Testing. Journal of Statistics Education, 16, 3. https://doi.org/10.1080/10691898.2008.11889575

Tsai, W., & Wardell, D. G. (2006). An interactive Excel VBA example for teaching statistics concepts. INFORMS Transactions on Education, 7(1), 125-135. https://doi.org/10.1287/ited.7.1.125

Tucker, M. C., Shaw, S. T., Son, J. Y., & Stigler, J. W. (2023). Teaching statistics and data analysis with r. Journal of Statistics and Data Science Education, 31(1), 18-32. https://doi.org/10.1080/26939169.2022.2089410

Volk, M., Cotič, M., Zajc, M., & Starcic, A. I. (2017). Tablet-based cross-curricular maths vs. traditional maths classroom practice for higher-order learning outcomes. Computers & Education, 114, 1-23. https://doi.org/10.1016/j.compedu.2017.06.004

Yates, F. (1934). Contingency tables involving small numbers and the chi-square test. Journal of the Royal Statistical Society, 1, 217-235.

Ziatdinov, R., & Valles Jr, J. R. (2022). Synthesis of modeling, visualization, and programming in GeoGebra as an effective approach for teaching and learning STEM topics. Mathematics, 10(3), 398. https://doi.org/10.3390/math10030398