THE EFFICIENCY OF THE APPLICATION OF SPSS IN HIGHER EDUCATION TEACHING: AN EXPERIMENTAL STUDY

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Abstract: Acquiring statistical education is a prerequisite for the professional and scientific work of every pedagogue. Institutional support for the statistical education of students is a fundamental starting point in the development of research competencies necessary for a future pedagogue. The subject of this study was focused on examining the effectiveness of the application of a program for statistical data processing in teaching. The research aimed to examine whether students gained adequate knowledge in the field of Statistics in Pedagogical Research by applying the experimental factor SPSS in teaching. This means that the use of the SPSS program may significantly facilitate the acquisition of theoretical and practical knowledge pertaining to the field of statistics in pedagogical researches. The objective was to analyze whether using the SPSS software as part of university education would yield better knowledge of statistics than teaching without it. This objective was accomplished by analyzing the differences in the respondents' scores on the knowledge test using the pre-test and the post-test groups of students. Three generations of pedagogy students at the Faculty of Philosophy, the University of Nis in Serbia, participated in the experimental research. The results showed statistically significant differences in the participants' achievement in the initial and final tests.

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Introduction

Statistics, as a complete scientific discipline, is applied in both natural and social sciences, which indicates its multidisciplinary character. The role of the statistical method in these sciences is not the same. In some scientific fields, it is the primary, exclusive research method, while in others, it is an auxiliary method. The wide application of the statistical method in studying education and social phenomena and processes is not accidental. It is applied primarily due to the tendency of the society to base its decisions on scientific, objective and precise bases and information.

Nowadays, statistics in pedagogical research are based on modern and multivariate statistical procedures. It has peaked in the era of statistical offices, journals, statistical bulletins, and yearbooks. The use of the statistical method has modernized pedagogical research and contributed to the confirmation of former theoretical assumptions, hypotheses and knowledge in a practical way.

An important goal of statistics is the development of statistical reasoning as a special technique of thinking. Generally accepted as the only reliable basis for making judgments about the efficiency of various procedures, statistics is obviously a scientific discipline whose impact on public and private life is enormous. The development of statistical reasoning is closely related to the development of inductive logic and the scientific method (Cabrini Grácio & Garrutti, 2006).

Statistics in pedagogical research has great significance and possibilities. Statistical procedures provide clarity, systematicity and precision in the study of pedagogical phenomena and their mutual connections, and they also enable the obtained data and research results to be arranged and connected into a meaningful whole. Proper application of statistical methods and procedures enables pedagogical research to be more scientific. It provides a more reliable basis for planning (designing) different segments of the development of the education system.

Pedagogues need certain theoretical knowledge, as well as practical skills for their application. Learning statistics is not reduced to memorizing statistical rules and patterns and calculating statistical parameters, but it involves providing learning opportunities which enable acquiring statistical concepts and laws and developing a statistical way of thinking (Cunningham, 1993). This ability includes theoretical factual statistical knowledge and specific knowledge necessary for the selection and application of appropriate statistical procedures, as well as astheoretical factual knowledge and specific knowledge necessary for the selection and application of appropriate statistical procedures and the interpretation of organized research data.

The course Statistics in Pedagogical Research aims to educate students to react intellectually to quantitative information in the world around them. One of the stated goals of education in the field of

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statistics is to develop a flexible way of solving statistical problems, statistical literacy, related communication skills and data analysis skills as opposed to transferring only computer and procedural skills, then forcing active learning through various lecture alternatives; respecting the power of statistical estimates (Jatnika, 2017; Rustam & Mashuri, 2018). Computer literacy, statistical logic, statistical thinking and the skill of mastering statistical procedures are prerequisites for research activities that are a condition for professional development, innovation of the teaching process and improvement of educational practice (Fullan, 1993). Research practice and statistical education imply theoretical knowledge and practical knowledge important for the selection and application of appropriate statistical procedures in research, as well as the presentation of results (Idris, 2018; Godino et al., 2008; Tishkovskaya & Lancaster, 2012).

The desire for students to become acquainted with statistical thinking has led to the recent rise of research in statistical education. Many students are initially "worried" about how they will master statistics because of its incomprehensible language, and especially because of the incomprehensible symbols they encounter in statistics (Gal & Garfield, 1997). The main reason for the resistance to statistics is based on the opinion that statistics is impossible to master without the knowledge of mathematics. However, this is not true, and the first step at the Bachelor's academic studies of pedagogy is to remove the barriers that students have at the beginning of the course. The main statistical principles and way of thinking can be acquired using logic entirely.

The age of the information revolution in which statistical data are rarely processed on paper by pen has bred numerous computer-based statistical programs that arrange data into tables very simple and accurate. One of the programs that marked the age of pedagogical researches and contributed to the modernization of pedagogical statistics teaching is the SPSS program. It should be emphasized that the goal of this research was not to promote the SPSS program in particular but to support any other program that could improve teaching and assist students in their study of statistical parameters and their application in practice, i.e., data processing after the "field" work. The principal goal was to show the effect of the experimental factor on the students' acquired knowledge. Moreover, the research discussed the importance of repeated measuring, i.e., testing to obtain the most valid statistical results.

As students, and later statistics lecturers at the university level, the authors saw and felt how attitudes and beliefs, especially negative ones, could directly impact the atmosphere in the classroom and the ability of each individual student to learn. Taking this into account, the goal of applying the SPSS in higher education was that students learn the basics of statistics to understand and evaluate information in the world better. The objective was to analyze whether using the statistics software as part of university education would yield better knowledge of statistics than teaching without it. This objective was accomplished by analyzing the differences in the respondents' scores on the knowledge test using the pre-test and the post-test groups of students.

Data and methodology

An experimental method with one pre-test and the post-test group was used in the study to examine the impact of the experimental factor on learning statistics by the practical application of the SPSS program in university teaching. Pedagogy students were subjected to the experimental research for three consecutive years to examine the role of statistical software for data processing (independent variable and experimental factor) on the students' achievement (dependent variable).

Table 1: Organization of research with one group – second-year pedagogy students	
	Pre-test
	The effect of the experimental factor (Teaching using SPSS)
	Post-test
Source: Authors	

The research was executed in three stages: preparatory stage, field stage and stage of analysis and interpretation of the research results. The research process itself was conducted on the student population to examine how identical the results were in each repeated experiment to examine the efficiency of the SPSS program in the realization of the course Statistics in Pedagogical Research. The research stages with students in three academic years were:

1. The initial measurement of pedagogy students' knowledge of statistical concepts;
2. Realization of the course Statistics in Pedagogical Research in the interval of 5 months;
3. Final measurement of pedagogy students' knowledge of statistical concepts.

We used the experimental method, the comparative method, and the descriptive research method in the empirical part. The testing technique was used with the knowledge test as an instrument in the field of statistics in pedagogical research. The test consisted of thirty-two questions, twenty of which were with alternative and multiple-choice questions and two with open-ended questions. The test was compiled based on the questions from the collection of pedagogical statistics exercises (Kundačina, M. i Gojkov, G., 1998).

The research was conducted three times. It included three generations of pedagogy students at the Faculty of Philosophy, University of Nis, who represented a suitable sample. The same number of students completed the test at the beginning of the semester and the end of the semester.

In the academic year 2017/2018, a total of 42 pedagogy students participated in the study. These were the students who attended the course Statistics in Pedagogical Research ($N = 42$).

In the academic year 2018/2019, a total of 43 pedagogy students took part in the study ($N = 43$). They completed the same knowledge test at the beginning and at the end of the semester, so that one pre-test and the post-test group were planned in the second testing stage, as well.

The third test took place in the academic year 2019/2020. Once again, pedagogy students participated in the initial and final measurement of knowledge of statistical concepts as part of the course Statistics in Pedagogical Research ($N = 44$). The presented structure of the participants indicates the homogeneity of the sample from one year to the next, as well as the equivalence of groups at the beginning and the end of the course.

In the academic years 2017/2018, 2018/2019 and 2019/2020, at the beginning of the spring semester, pedagogy students who attended Statistics in Pedagogical Research were given an initial test of knowledge about the basic statistical parameters. After that, the students attended regular lectures and tutorials every week, whereby tutorials focused on processing each thematic unit with the help of the SPSS, a software for statistical data processing. Tutorials took place in a multimedia classroom, where each student had the opportunity to learn and perform tasks on a computer. The success of teaching through multimedia content and the SPSS was checked for three consecutive years. During the last class of the course, the students completed the same test as at the beginning of the course, which enabled the researchers to observe the success of teaching.

The research process was retested with the aim of examining the efficiency of teaching different generations of students with the aim of making the most valid conclusions about the research results.

Results and discussion

Statistics in Pedagogical Research has a large impact on the formation of a pedagogue. It is important for students to not only acquire the theoretical knowledge, but also practical, statistical knowledge that they will apply in pedagogical research. The model of building statistical education should be based on active participation in research practice during studies - learning based on experience. Until a few decades ago, statistical data processing was performed in specialized centers at universities or research institutes. In previous years, courses in statistics were realized using the pen-and-paper technique, which is why it was necessary to know mathematical formulas in order to learn statistics. Precisely that kind of statistical processing often required much time and effort. While there used to exist no computer, programs dedicated to statistical data processing and scientific material were not interpreted in a modern way, today, with the development of computers (PCs), opportunities are created for every researcher to perform data processing.

Pedagogy students get acquainted with statistics and statistical terminology even before the very beginning of the course Statistics in Pedagogical Research - in the first semester of the second year, as part of the course Methodology of Pedagogy. It is quite logical that the knowledge of pedagogy students at the beginning of the semester is much scarcer than when testing student achievement at the end of the semester. The experimental research enabled us to examine the effectiveness of the program of Statistics in Pedagogical Research. However, the researchers' interest was only to gain insight into the final measurement results, i.e., post-test, and to be able to compare the results from each academic year.

The test was first carried out in 2017/2018, and then again in 2018/2019 and 2019/2020, in order to examine whether similar results would be obtained in each test and confirm that the results in the first test were not random.

Table 2: First pre-test and post-test of knowledge of general concepts in statistics			
		%	
	Pre-test	11	
	Post-test	91	
Source: Authors			

During data processing, the participants' answers were divided into two categories: *correct* answers and *incorrect* answers. At the beginning of the semester, in the first test, a small percentage of students solved the knowledge test, i.e., 11% of students solved the statistics knowledge test successfully in the initial measurement, while in the final measurement, the test was solved by 91% of the total number of participants (N = 42).

Table 3: Differences in the knowledge of statistics in the pre-test and post-test							
	Pair 1	M	N	SD	t-test	df	p
	Pre-test	66.3810	42	6.18215	2.080	41	0.044
	Post-test	69.3095	42	5.85996			
Source: Authors							

The first test concludes that the correct answers on the knowledge test are in favor of the post-test. The difference between pre-test and post-test knowledge is significant at the level of statistical significance, $p < 0.05$: $p = 0.04$. In addition to these data, a positive correlation between the effect of the SPSS program and the acquired knowledge in the final measurement is confirmed. The correlation is positive and at the level of statistical significance, $p < 0.05$.

Table 4: Second pre-test and post-test of knowledge of general concepts in statistics			
Retest procedure			
		%	
	Pre-test	9	
	Post-test	89	
Source: Authors			

Table 4 shows the ratio of correct and incorrect answers on the statistics knowledge test in the initial and final measurement. Like in the first testing stage, there is a noticeable increase in the percentage of correct answers on the post-test. Namely, 89% of students successfully solved the knowledge test in the final measurement. In the first test, a significantly smaller percentage of students answered the questions correctly (9%), N = 43.

Table 5: Differences in the knowledge of statistics in the pre-test and post-test of the second testing stage							
	Pair 1	M	N	SD	t-test	df	p
	Pre-test	37.7674	43	5.07158	9.348	43	0.001
	Post-test	55.3953	43	7.91875			
Source: Authors							

The difference between pre-test and post-test knowledge is significant at the level of statistical significance, $p < 0.05$: $p = 0.01$. Students showed knowledge in the field of statistics in the final measurement, and in relation to the pre-test, this difference is significant at the level of statistical significance. As with the previous measurements, the connection between knowledge in the pre-test and post-test was examined. The correlation is positive at the level of statistical significance, $p < 0.05$.

Table 6: Third pre-test and post-test of knowledge of general concepts in statistics			
Retest procedure			
		%	
	Pre-test	12	
	Post-test	92	
Source: Authors			

The ratio of achievements on the pre-test and the post-test is identical to the previous two years. We obtained approximately similar research results for the third generation covered by the research, $N = 44$ (Table 6).

Table 7: Differences in the knowledge of statistics in the pre-test and post-test of the third testing stage

Pair 1	M	N	SD	t-test	df	p
Pre-test	38.2273	44	5.16672	9.468	43	0.001
Post-test	55.1591	44	7.33854			

Source: Authors

Differences in student achievement are significant at the level of statistical significance, $p < 0.05$: $p = 0.001$. As expected, knowledge reached higher values in the final measurement than in the initial measurement of this quasi-experimental study.

In the third test, the relationship between the performance of the SPSS program and the acquired knowledge in the final measurement was examined using correlations. The relationship was positive and the increase in knowledge was present in the final measurement of the knowledge of statistical concepts, $p < 0.05$. With this retest, we are on the verge of determining that the correlative relationship is actually a cause-and-effect relationship. The increase in the students' knowledge is attributed to lectures and tutorials during the semester and the use of SPSS for statistical analysis data processing.

Finally, we examined only the relationship between the achievements in the final knowledge measurements for all three generations of students. The results of the study are shown in Table 8.

Table 8: Differences in the knowledge of statistics in the final measurements of all three tests

Knowledge	Sum of the scores	df	M (S)	F	p
2017	222.893	9	24.766	1.120	0.377
2018					
2019					

Source: Authors

We found that similar data were obtained in all three tests by conducting the previously mentioned statistical analysis. In order to draw a conclusion with certainty, we examined the differences in student achievement on the post-test knowledge test by using the process of variance analysis. As there was an evident difference in the pre-test and post-test, it was important to determine whether there were differences in the final measurements in order to conclude with certainty that the quasi-experimental study in all three measurements was identical. By comparing the post-tests of all three testing stages, it was noticeable that there were no statistically significant differences between the observed groups, $p > 0.05$: $p = 0.38$. These data confirm the homogeneous achievements in the final measurements in all tests.

Table 9: Some of the participants' most common answers to open-ended questions

<p>Excerpts from tests of knowledge of general concepts in Statistics in Pedagogical Research</p> <p><i>What do you expect from the course Statistics in Pedagogical Research, and do you have prior knowledge relevant to this course?</i></p> <p>—I expect to master working with SPSS.</p> <p>—I want to learn what can be statistically presented and expressed.</p> <p>—I expect to learn the terminology that accompanies this course successfully.</p> <p>—I want to learn everything that I will need for further education and to acquire the knowledge necessary to pass the final exam.</p> <p>—I expect to learn the basics of statistics in pedagogical research and to pass this exam.</p>
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Source: Authors

The model of building statistical education should be based on active participation in research practice during studies - learning based on experience. Pedagogy students in their second year already know the methodology well. They can conduct research, and they learn how to analyze and interpret the obtained findings in the course Statistics in Pedagogical Research.

Conclusion

So far, there has been no research that examines the efficiency of the SPSS program in higher education in Serbia. Acquiring statistical literacy is a prerequisite for dealing with the professional and scientific

work of every pedagogue. Conducting applied, experimental, sociometric, comparative, operational, basic or any other pedagogical research in school is inconceivable without applied statistics. The selection of the data processing program is primarily conditioned by the analytical experience and preferences of the researcher, teacher and practitioner; however, this choice also depends on the availability of the program package, accompanying resources and adequate support in an institution of higher education. The presented research used the SPSS program as an instrument necessary to improve statistical knowledge in pedagogical research.

When students of social sciences faculties (pedagogy, sociology, psychology) are surprised that they have to take a course in statistics, they often comment that they enrolled in the mentioned faculties precisely because they do not like, and do not know mathematics. So, they equate statistics with mathematics. This attitude is a consequence of a lack of understanding of what makes the application of the statistical method essential and the incomprehensibility of statistical language, differences in statistical symbols for the same measures, methodically unformed textbooks, and similar issues. The collected empirical material is very extensive, which is why it is difficult process it by hand. For many years, computers have been used for statistical processing of more extensive databases. Several programs are used for statistical processing. The most comprehensive and complete program for social sciences and humanities students is SPSS (Statistical Package for Social Sciences). Like many other programs, SPSS is constantly evolving and being supplemented. We can say that this program will be used for a long time. We believe that SPSS will change in the upcoming years, but the basic approach to work will remain the same or very similar. It is essential to emphasize that this research did not intend to promote or favor the SPSS program. Quite the contrary, its aim was to indicate potential implications of applying other available software for the statistical data analysis and examine their impact on students' final scores when testing their acquisition of statistics and statistical deduction. Regarding the presented experimental research, this program helped students acquire the knowledge of statistics, the subject that causes anxiety with no justifiable reasons saves insufficient information.

Learning statistics is not reduced to memorizing statistical rules and patterns and calculating statistical parameters, but it involves providing learning opportunities that enable acquiring statistical concepts and laws and developing a statistical way of thinking. The course Statistics in Pedagogical Research at the Faculty of Philosophy, University of Niš insists on that. This research aimed to show how innovative teaching and any change in teaching can result in good student achievement.

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