European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available on-line at: www.oapub.org/edu

doi: 10.5281/zenodo.223834 Volume 3 | Issue 1 | 2017

SCIENTIFIC AND METHODOLOGICAL SOUNDNESS OF EXPERIMENTS IN PEDAGOGICAL RESEARCH

Mile Ilić[1], Ljiljana Jerković[2]

[1]Ph.D, Full professor of specialised scientific disciplines of Didactics,
General Pedagogy and Class Teaching Methods
Faculty of Philosophy Banja Luka, University of Banja Luka
Bosnia and Herzegovina

[2]MA, Teaching assistant of specialised scientific disciplines of Didactics and General Pedagogy
Faculty of Philosophy Banja Luka, University of Banja Luka
Bosnia and Herzegovina

Abstract:

The experimental method is more exact compared to other quantitative methods, although it can have drawbacks, related to the positivist epistemological position. Determining exactly the educational effects of existing, innovative and new pedagogical concepts, programmes, systems, models, methods and instruments commands the use of experiments in pedagogical research. If completed pedagogical research projects are analysed, the conclusion is experiments are used much less frequently than other methods.

This study determines the prevalence of parallel-group designs as compared to how frequently other experimental designs are used. A representative sample of scientific and professional papers was analysed and it was ascertained that the conducted experiments partly satisfy relevant theoretical and methodological criteria. It is evident that result reliability when using the experimental method is still relatively low, which may have negative effects on the development of pedagogical sciences and related scientific disciplines, as well as on scientifically grounded innovation of the teaching and learning process and enhancement of the educational process. Hence, it is crucial to use multi-method research approaches (employing the experimental method as appropriate, depending on the research problem) in preparing (and approving) doctoral dissertations, writing reviews and publishing research papers.

Keywords: experiment, experimental design, parallel-group experimental design, pedagogical research, multi-method research approach

Introduction

The experimental method is indisputably of great value for pedagogical research. The goal of experiments is not only to establish the cause and effect relationships between the studied phenomena, but also to study the effects of new concepts, procedures, strategies, methods, models and systems of work on teaching and learning and the educational process. The experimental method, as used in pedagogical research, is not an end in itself. Its purpose is to increase and expand the scope of knowledge of pedagogy, thereby enhancing the teaching and learning process and educational activity.

Similar to many other research methods, the experimental method has its advantages and limitations. The value of an experiment depends on the extent "*the researcher is capable of and can expend the effort required to ensure the right experimental conditions, select the most appropriate design, successfully carry out the right experimental procedure, and is also ready to surmount difficulties accompanying experimentation in this field, arising from the complex nature of pedagogical sciences, as well as their other characteristics*" (Kocić, 1981, p. 143). Therefore, the experiment is a highly sophisticated method whose effectiveness will depend on the researcher's readiness to take account of all its advantages and potential weaknesses in the process of application, while studying a specific problem.

Some potential benefits of using the experimental method in pedagogical research are:

- The researcher does not need to wait for the right opportunity to conduct research, but can instead create such opportunities;
- Research results can be verified, i.e., an experiment can be repeated;
- In comparison with other methods, it allows the establishment of the cause and effect relationships between the independent variable and the dependent variable with greater certainty, as long as it is applied with a degree of caution;
- It offers the possibility of stricter and more efficient control of the research conditions (ibid., pp. 136-137).

Quantitative research methods, which also include the experimental method, are grounded in the philosophy of logical empiricism or positivism. Essentially, logical empiricism postulates that certain kinds of reliable conclusions can come from experience alone (Cohen, Manion & Morrison, 2007, p. 10). Accordingly, only experiential facts can be the subject of scientific cognizance. Bogdan Šešić claims that, according to the philosophy of logical positivism, "*the main subject of all empirical sciences*

is empirical facts, i.e., sensations, sensuous impressions and perceptions, their direct experience, that is, cognizance in the form of factual judgements" (Šešić, 1974, p. 128).

The main weakness of the experimental method (as well as of other quantitative methods) is attributed to the positivist epistemological position, which makes it impossible to fully understand the essence of the studied phenomenon, as it disregards the situational context. Slavo Kukić claims that a quantitative approach, which is also a characteristic of the experimental method, is always partial, because it tests only a certain number of hypotheses, and not the whole phenomenon (Kukić, 2015, p. 117). Stanislav Fajgelj stresses that "*experiments cannot be successfully conducted*" (Fajgelj, 2014, p. 223). An experiment can never be fully controlled, as planned by the design. It is difficult to preclude interaction between group members. Also, junior researchers often proceed at will (ibid., p. 223).

Pedagogical literature on the topic of methodology lists the following kinds of experiment designs:

1. One-group design;
2. Parallel-group design;
3. Factor rotation design/factor analysis; and
4. Ex post facto design (Banđur & Potkonjak, 1999; Mandić, 2004; Savićević, 1996)

One-group designs are the kind of experiment designs in which one or more factors are introduced to one group, and its or their effects monitored relative to the original examination (Mandić, 2004).

Parallel-group designs include working with at least two groups of research subjects. An experiment factor is introduced in working with one of the groups (e.g., a new system of teaching and learning, procedure, programme/syllabus), whereas the other group is the control group, which the researcher works with using the traditional (usual) approach (Banđur & Potkonjak, 1999).

In factor rotation designs, all experiment factors are successively introduced to all groups of research subjects (Banđur & Potkonjak, 1999; Mandić, 2004).

Ex post facto designs study the cause and effect relationships that exist between pedagogical phenomena or in the educational process itself, without introducing any experiment factors. The "experiment" factor already exists, as it was previously introduced by someone else (Banđur & Potkonjak, 1999).

Practically, all of the designs listed above have their virtues and downsides. According to pedagogical methodology literature, parallel-group designs are conducted the most frequently and are also the most reliable. One of the aims of this study was to determine the frequency of use of this type of experiment design.

Methodology

Research goal

The goal of this research is to ascertain the prevalence and exactness of the experimental method as used in pedagogical research.

Hypotheses

1. It is expected that experiments are conducted significantly less often in pedagogical research than the descriptive method is employed;
2. It is assumed that the frequency of use of parallel-group designs in pedagogical research is more statistically significant compared to other experimental designs;
3. For most of the pedagogical research studied herein, the conducted experiments partly satisfy the theoretical and methodological criteria listed below:
   - 3.1. Thematic relevance of the experiment;
   - 3.2. Theoretical soundness of the experiment;
   - 3.3. Extent of reliance on previous research;
   - 3.4. Explicitness of the experiment factor (independent variable);
   - 3.5. Concreteness of the dependent variables;
   - 3.6. Equitability of relevant variables;
   - 3.7. Relevance of research tools relative to the research theme, content and problem;
   - 3.8. Explicit description of the experimenter training programme;
   - 3.9. Duration of the experiment;
   - 3.10. Appropriateness of the statistical procedures used for data processing;
   - 3.11. Full interpretation of the experiment results;
   - 3.12. Degree of verification of the suggested hypothesis;
   - 3.13. Consistency in drawing conclusions (making scientific generalizations);
   - 3.14. Degree of contribution to science (novelty);
   - 3.15. Explicit description of result applicability; and
   - 3.16. Presentation of identified problems to be dealt with in future research.

Research tool

The research tool used for the needs of this study was the protocol of analysis of the experimental method appropriateness for pedagogical research relative to content and the research problem.

Study sample

The study sample included 147 scientific works (31 doctoral dissertations, 66 master theses, 19 research monographs and 31 research papers) and 63 professional (master) papers, of which 105 were the result of empirical research.

The sample was taken from the host of research works published in the framework of activity of two teacher training faculties – The Faculty of Philosophy in Banja Luka and The Faculty of Philosophy in Pale. The sample comprised approximately 80% of the doctoral dissertations and master theses (both pre-Bologna and Bologna systems) from the period between 2000 and 2015, as well as over 10% of the research monographs and papers written in the same period by professors and instructors from the two institutions. The sample included approximately 80% of all works from the period 2000 to 2015. The subsample comprised 30 research works in which the experimental method was used. The experiment was the unit of analysis of the work contents.

Results and discussion

While acknowledging the importance of the experiment as a research method, this study attempts to ascertain its frequency compared to the descriptive method as used in pedagogical research.

Table 1: Experimental method in pedagogical research

Method	N	%	χ^2	p
Experimental	30	28.57		
Descriptive	75	71.43	19.29	0.00
Total	105	100		

According to the indicators presented in Table 1 and the chi-squared distribution (χ2=19. 29; p=0.00), it is possible to conclude that in terms of statistical significance, the experimental method is far less frequently used in didactic and methodological research (28.57%) than the descriptive method (71.43%), which confirms our first auxiliary hypothesis. The fact that the descriptive method prevails in pedagogical research suggests that the situation in the classroom and educational reality is mostly described as it is. Insights like this can be stimulating for further research, including experimental research; sometimes, they can be developmental and strategic in nature. The purpose of the descriptive method is not simply to describe a phenomenon under consideration, but to interpret, compare and contrast data, with the aim of making scientific generalisations. Such generalisations are often declarative. Does it suffice to simply describe the situation as it is, which is also quite often unfavourable, make declarative generalisations and identify new issues, and by doing so make improvements in the area of teaching and learning and educational activity? Can description be used to effect scientifically grounded change in teaching and learning and the educational process?

We were interested in the extent to which specific experiment designs are used in pedagogical research.

Table 2: Prevalence of different experiment designs in pedagogical research

Experiment designs	N	%	χ^2	p
Parallel-group design	28	93.33		
Other experiment designs	2	6.67	22.53	0.00
Total	30	100		

According to the statistical indicators shown in Table 2, the prevalence of parallel-group designs (93.33%) is evident when compared to other designs, corroborating our second auxiliary hypothesis. Parallel-group designs are the most reliable, since the use of the control group allows the researcher to determine the impact of the experiment factor (a new system of teaching and learning, a new procedure, strategy, etc.), on condition the experimental group and the control group are equivalent. As it is impossible to achieve absolute group equivalence, parallel-group designs cannot be considered fully reliable.

We were interested in seeing to what extent research projects meet the relevant theoretical and methodological criteria.

Table 3: Scientific and methodological soundness of the experimental method in pedagogical research

Criteria of scientific and methodological soundness of experiments	Identified degree of fulfilment of criteria								χ^2	p
	does not satisfy the criteria		barely refers to the criteria		satisfy the criteria		fulfil the criteria			
	N	%	N	%	N	%	N	%		
1. Theoretical soundness of the experiment	0	0	2	6.7	14	46,7	14	46.6	9.73	0.05
2. Thematic relevance of the experiment	0	0	5	16.7	0	0	25	83.3	7.80	0.05
3. Extent of reliance on previous research	3	10.0	7	23.3	6	20.0	14	46.7	5.00	0.29
4. Explicitness of the experiment factor (independent variable)	2	6.7	8	26.7	7	23.3	13	13.3	5.67	0.22
5. Concreteness of the dependent variables	1	3.3	4	13.3	8	26.7	17	56.7	7.67	0.10
6. Equitability of relevant variables	2	6.7	3	10.0	5	16.7	20	66.6	10.00	0.05
7. Relevance of research tools relative to the research theme, content and problem	0	0	0	0	7	23.3	23	76.7	5.40	0.07
8. Explicit description of the experimenter training programme	22	73.3	5	16.7	2	6.7	1	3.3	38.53	0,00
9. Appropriateness duration of the experiment to the complexity of the research problem	4	13.3	10	33.3	11	36.67	5	16.6	4.93	0.18
10. Appropriateness of the statistical procedures used for data processing	0	0	1	3.3	8	26.7	21	70.0	7.60	0.05

11. Full interpretation of the experiment results	0	0	4	13.4	13	43.3	13	43.3	8.13	0.05
12. Degree of verification of the suggested hypothesis	0	0	1	3.3	10	33.3	19	63.4	10.80	0.05
13. Consistency in drawing conclusions (making scientific generalisations)	0	0	7	23.3	9	30.0	14	46.7	1.46	0.69
14. Degree of contribution to science (novelty)	1	3.3	9	30.0	12	40.0	8	26.7	13.00	0.01
15. Explicit description of result applicability	11	36.7	7	23.3	3	10.0	9	30.0	6.66	0.15
16. Presentation of identified problems to be dealt with in future research	20	66.7	1	3.3	3	10.0	6	20.0	42.66	0.00

According to the data given in Table 3, the majority of the papers analysed satisfy or fulfil the following requirements of theoretical and methodological soundness of the experiment: theoretical soundness and thematic relevance of the experiment; equitability of the relevant variables; relevance of research tools relative to the research content and problems; appropriateness of the statistical procedures used; comprehensive interpretation of the research results; verification of the proposed hypotheses; and a degree of scientific novelty.

The thematic relevance and theoretical soundness of the experiment, along with equitability of the relevant variables, reduce the possibility of improvisation and arbitrariness in education research. The results of this study show that the research projects investigated herein mainly meet the criteria stated in this paragraph.

According to the indicators in the same table, the majority of the research tools as employed in the examined works satisfy or fulfil the criteria of relevance relative to the research content and problems, which makes this a barely detectable statistically significant difference. Adequate research tools are an important condition for the validity of research results.

According to the data stated in Table 3, a significantly high number of the works meet to a certain degree the criterion of appropriateness of statistical procedures relative to the studied phenomenon ($\chi 2=7.60$; $p=0.05$). The research results may also be considered comprehensively interpreted ($\chi 2=8.13$; $p=0.05$).

Hypothesis verification allows the researcher to set a framework within which to make conclusions and generalisations. A great majority of the works examined state whether the set hypothesis has been adopted or rejected, compounded with relevant fact-based explanations ($\chi 2=10.80$; $p=0.05$).

According to the statistical indicators presented in the same table, for the majority of the works examined there is no significant difference in terms of the following criteria of theoretical and methodological soundness of the experiment:

reliance on previously conducted research; explicit description of the experiment factor; description of the dependent variables; an appropriate duration of the experiment; complexity of the research problem; consistency in drawing scientific generalisations; and stating research result applicability.

The statistical indicators show that every third experiment does not rely on the results of previously conducted empirical research, which means they do not sufficiently meet the requirement of continuity meant to increase and expand scientific knowledge. Failure to take into consideration the results of previously conducted research often leads to "*researching previously researched problems"* and *"discovering previously discovered truths*".

One-third of the works is merely close to or does not satisfy the criterion of explicitness of the experiment factor. Two-thirds of them satisfy or fulfil this criterion. Failure on the part of the researcher to explicate the independent variable is conducive to doubt as to the exactness of the research and precludes the experiment from being repeated by other researchers.

The dependent variable has to satisfy two important requirements. It is important that it be an adequate representation of the research construct and reliably measurable and perceivable (Milas, 2009, p. 113). Every sixth study or work does not satisfy or barely refers to the criterion of precise definition of dependent variables.

The experiment duration depends on the complexity of the experiment factor. The more complex and sophisticated the factor, the longer the experiment. Studying the impact of a factor on rote learning is certainly different from examining its influence on student-held values. The data presented in the table indicate that for approximately one half of the pedagogical works examined in this study the experiment duration corresponded to the phenomenon complexity, whereas for the other half it did not.

Also, the majority of these pedagogical works satisfy or fulfil the criterion of consistency in drawing scientific generalisations. The scientific generalisations made "crown" the conducted research. As far as contemporary didactic and methodological research is concerned, it is absolutely necessary to refer to the possible applications of research results in the classroom and educational practice, as well as their dissemination. More than a half of the studies or works analysed (approximately 60%) do not write about or barely mention the applicability of their research results. The ultimate goal of research is not "*scientific cognizance for the sake of scientific cognizance*", but rather the enhancement of teaching, learning and educational activity. Pedagogical research which does not address the issues of applicability and dissemination of its results is of questionable value.

According to the data in Table 3, the majority of the analysed papers and works do not satisfy the following criteria of theoretical and methodological soundness of the experimental method: explicitness of the experiment factor (independent variable) and raising new issues and problems. Over 85% of the papers and works do not provide a

description of a specific experimenter training programme. These data may signal that an experiment may have been arbitrarily conducted, which undoubtedly affected the validity of the obtained results. Apart from training the experimenters to carry out the experiment, it is worthwhile to hold weekly meetings of the researcher and the experimenters, where problems can be dealt with jointly and notes taken with regard to how frequently specific problems appear. This type of information can be useful when evaluating the experiment results, which may or may not tally with the researcher's expectations (McGowan, 2011, p. 5).

There is a statistically significant difference between the analysed works in terms of presenting problems identified to be addressed in further research. Namely, the number of pedagogical experimental research projects which do not write about problems to be addressed by researchers in the future (over 70%) is greater than those that do. Such a treatment of research results on the part of researchers does not contribute to the advancement of scientific knowledge.

In accordance with the above analysis, it may be concluded that the third hypothesis has been confirmed, i.e., the conducted experiments partly satisfy the necessary theoretical and methodological criteria.

Conclusions

Researchers' preferring other methods to the experimental method as used in pedagogy undoubtedly has negative consequences on the development of the system of scientific pedagogical knowledge, the innovation of teaching and learning and the enhancement of the education process. While it is necessary to bear in mind the potential limitations of the experimental method, its advantages compared to other research methods must not be disregarded either.

In light of the results of this study into the frequency and quality of the experimental method as employed in pedagogical research, it may be considered necessary to do the following:

1. Significantly increase the number of thematically, theoretically and methodologically appropriate experiments that will optimally take account of previously conducted empirical research, clearly describe the experiment factor (independent variable), present, in detail, the procedure and content of experimenter and researcher training, make explicit the areas of application of the research results and state the remaining problems to be addressed by research in the future.
2. Significantly improve the methodology of experimental research, thereby optimising its contribution to the advancement of pedagogical scientific disciplines, which will have an effect in the sense of enhancement, grounded in

science, of the process and outcomes of teaching and learning activity and the education process.

3. Interpret research results employing both quantitative and qualitative approaches, by making more permanent and higher quality scientific syntheses;
4. Take into consideration the above presented methodological criteria of valuation of the exactness of experimental research, which may help lessen the use of pseudo-methods and the gaining of quasi-scientific results and insights in experimental pedagogical research.

References

1. Банђур, В. и Поткоњак, Н. (1999). *Методологија педагогије.* Београд: Савез педагошких друштава Југославије.
2. Cohen, L., Manion, L. & Morrison, K. (2007). *Metode u istraživanja u obrazovanjuc* (prevod petog izdanja). Zagreb: Naklada Slap.
3. Fajgelj, S. (2014). *Metode istraživanja ponašanja* (V dopunjeno izdanje). Beograd: Centar za primenjenu psihologiju
4. Kocić, Lj. (1981). *Pedagoški eksperiment – karakteristike i mogućnosti.* Beograd: Institut za pedagoška istraživanja i Prosveta.
5. Kukić, S. (2015). *Metodologija znanstvenog istraživanja.* Sarajevo: Sarajevo publishing.
6. Мандић, П. (2004). *Методологија научног рада.* Бања Лука: Академија наука и умјетности Републике Српске.
7. McGowan, H. M. (2011). *Planning a Comparative Experiment in Educational Settings.* Journal of Statistics Education, Volume 19, Number 2.
8. Milas, G. (2009). *Istraživačke metode u psihologiji i drugim društvenim znanostima.* Zagreb: „Naklada Slap".
9. Mužić, V. (1968). *Metodologija pedagoškog istraživanja.* Sarajevo: Zavod za udžbenike i nastavna sredstva.
10. Savićević, D. (1996). *Metodologija istraživanja u vaspitanju i obrazovanju.* Vranje: Univerzitet u Nišu Učiteljski fakultet u Vranju.
11. Šešić, B. (1974). *Osnovi metodologije društvenih nauka.* Beograd: Naučna knjiga.