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Research Article

Primary school teachers' attitudes towards experimentation in physics teaching

Ioannis Vlachos [1]
0009-0005-1609-8625

Georgios Stylos [1*]
0000-0001-8036-8427

Konstantinos T. Kotsis [1]
0000-0003-1548-0134

[1] Department of Primary Education, University of Ioannina, Ioannina, GREECE
[*] Corresponding author: gstylos@uoi.gr

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ABSTRACT

The physics' subject aims to provide the student with a broad understanding of the physical phenomena that occur around them every day and introduce them to the scientific search. The use of experiments in the teaching of the subject contributes to the understanding of these phenomena, the development of skills and critical thinking and has many benefits for the emotional, social and psychomotor fields of the students. In total, 178 primary school teachers who have taught physics from West Greece, were enrolled in our study. All participants completed a questionnaire electronically, based on teachers' attitudes towards physics teaching on specific factors. No differences were found between genders, teachers' attitudes towards the use of physics experiments are not affected by their years of service with minor exceptions, while teachers develop more positive attitudes towards experiments over the years of teaching physics. Moreover, teachers' field of study plays an important role on their attitudes towards experiments, there are no differences to the age group of teachers and their attitude towards the use of experiments in the teaching of physics with an exception. Though further research is needed, our questionnaire helps to identify factors that affect teachers' attitudes towards performing experiments in physics teaching.

Keywords: physics, experiment, teaching, attitudes, primary school teachers

INTRODUCTION

Physics is based on valid experimental evidence, rational discussion and review, provides us with knowledge of the natural world, while experiments constitute the evidence that supports this knowledge and they play many roles in science, such as evaluating theories, providing the basic scientific knowledge principles and explaining a theory's form or mathematical structure (Franklin & Perovic, 2021). Therefore, experimental teaching in physics is an integral component that provides a starting point for constructing and understanding knowledge. Experimental teaching of physics has an important role in the teaching of natural sciences and almost all textbooks highlight that physics is an experiment-based science in which adequacy is based on experiments (Koponen & Mantyla, 2006).

Experiments are useful as they allow students to observe phenomena, test hypotheses and apply phenomena to understand the natural world. More specifically, experiments in physics teaching are used to attract students' interest, provide them with clear examples of complex concepts, help them understand the operation of technical devices, and verify various predictions, theories, and models (Chiaverina & Vollmer, 2005). At the same time, a better level of education is performed among students when they measure, touch, feel, graph, manipulate, draw and record data, making the teaching of physics more effective (Ates & Eryilmaz, 2011). Also, experiments in physics teaching encourage students to use the scientific process for solving problems, making decisions, understanding the nature of science and technology, and critically analyzing newly provided scientific knowledge and its role in human society (Ozkal et al., 2010). Physics learning can be improved through its experimental teaching and the methods that experiments are conducted in the classroom within the constructivism theory (Duit & Confrey, 1996). Students' attitudes and motivation for science are more positive when experiments are performed (Gott & Dugan, 1996). Also, as a hands-on process, experiments increase students' autonomy when engaging in open-ended problems (Olsen et al., 1996). A key prerequisite for the success of experimental teaching is the recognition of the goals of the experiment by both the teacher and the students (Hodson, 1996).

As a type of inquiry-based learning, experimentation requires a combination of knowledge and skills. Therefore, the process includes the developing of an understanding of the scientific aspects involved: identifying and correctly formulating research questions, formulating hypotheses and/or predictions, designing, managing and conducting research to gather evidence, analyzing and evaluating data, interpreting results, developing explanations, participating in evidence-based arguments and the scientific communication in different situations at all stages of research (National Research Council [NRC], 2012).

Several teachers often have doubts and are more cautious in performing physics experiments. This may occur because the experiments are more time-consuming, and the appropriate equipment and resources are not always available. Furthermore, another limitation is that there is no control over external variables that could affect the experiment results (McLeod, 2012). Many primary school teachers stated that they had been trained in experimental teaching methods. Still, they find it difficult to put them into practice and feel a lack of competence to teach experiments in physics (Gunes et al., 2011). They find it difficult to answer students' questions about natural sciences and because of this difficulty, they prefer traditional teaching with textbooks or standardized exercises (Jarvis & Pell, 2004). Teachers' attitudes and beliefs about natural sciences are shown to be correlated with their intention to teach it in the classroom (van Aalderen-Smeets & van der Molen, 2013) and the practices they apply while teaching it (Haney et al., 2002). Primary school teachers with negative attitudes towards natural sciences spend less time teaching natural sciences subjects (Jarvis & Pell, 2004). A reason, also, for having negative attitudes towards experimentation in physics is that they did not had been taught lessons in physics experimentation in the early phase of their education in primary school (Yesilyurt, 2004).

Attitudes are related to coping with and managing the emotions that occur during the learning process and play an important role in human behavior. Whether positive or negative attitudes are part of a value and belief system, they directly affect students' performance and psychological status (Sunbul et al., 2004).

While teaching, most physics teachers concentrate on the subject's theoretical approach and not on performing experiments. The above approach may be due to the teachers' attitudes and beliefs (Haagen-Schützenhöfer & Joham, 2018). Teachers' ability to integrate experiments in physics teaching directly relates to their understanding of the subject (Andersen et al., 2019). There is also a strong correlation between the number of experiments during physics teaching and beliefs about their effectiveness (Lee & Ryu, 2018). Teachers with positive attitudes towards science feel less anxious when teaching and they are less dependent on the context (materials for teaching, available teaching time), while their attitudes towards science improve when they use inquiry-based teaching methods (van Aalderen-Smeets et al., 2017). Also, teachers with more scientific attitudes towards natural sciences have more positive attitudes towards teaching them. The more important they consider that natural sciences are, the more pleasure they feel when teaching them (van Aalderen-Smeets & van der Mollen, 2013). The better the teacher understands the subject, the more positive their attitudes towards teaching it (McDonald et al., 2019). Teachers, who have been taught scientific research in natural sciences, have positive attitudes and specifically, they feel more pleasure and less anxiety in teaching them (Riegle-Crumb et al., 2015). Many teachers have insufficient scientific knowledge and negative attitudes (Denessen et al., 2015; Osborne & Dillon, 2008; Osborne et al., 2003; van Aalderen-Smeets et al., 2012, 2017). Primary school teachers with negative attitudes towards natural sciences spend less time discussing and teaching natural sciences and are less able to stimulate their students to have positive attitudes towards them (Goodrum et al., 2001; Jarvis & Pell, 2004; Osborne et al., 2003). Conversely, it has been shown that when teachers become more confident in teaching natural sciences, students also gain higher levels of achievement in their classrooms (Lumpe et al., 2012).

Based on the above, teachers' attitudes towards integrating experiments in teaching, emerge as an important issue regarding the teaching of natural sciences. Last but not least, the extremely limited literature on this topic creates the necessity to investigate this issue further.

Purpose of Research: Research Questions

This research study aims to investigate the attitudes towards experimentation in physics teaching of primary teachers in Greece. More specifically, the study's objective is three-fold and sets out to investigate:

(1) the multidimensionality of the research instrument,

(2) the levels of primary teachers' attitudes, and

(3) differences in scores on the instrument components according to gender, general teaching years, physics teaching year and possession of master's degree.

METHOD

Sample

A convenience sample was selected and included 178 (70 male and 108 female) primary school teachers who have taught physics in four neighboring prefectures of West Greece. The questionnaire was distributed and completed electronically, as the research was conducted during the COVID-19 pandemic period.

Instrument

The instrument used for this study was a modified version of the research tool developed by Stylos et al. (2016). It consists of 22 items scored on a five-point Likert scale ranging from 1 (=totally disagree) to 5 (=totally agree). The questionnaire also included demographic variables (gender, years of teaching service, possession or not of a master's degree, years of teaching physics).

Statistical Analysis

Statistical analysis was performed with the IBM SPSS statistics 26.0. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) validated the appropriateness of the instrument. To address the study's proposed goals, the data were analyzed in the following additional steps. Firstly, Kaiser-Mayer-Olkin (KMO) measure, which is the most popular diagnostic measure, was used to test the correlation and appropriateness of factorization of the questions. Its values range from zero to one, with values close to one representing factorization of the questions and values less than 0.5 representing inappropriateness for factor analysis. For further examination of the suitability of the data for factor analysis, Bartlett's test of sphericity was conducted, which investigates as initial hypothesis the correlation between the variables.

Secondly, EFA was used for the analysis of the questions. Specifically, principal component analysis PCA) method was applied to extract the factors by orthogonal rotation of the axes using the Varimax method, which, according to Hair et al. (1995) and Sharma (1996), is one of the most popular orthogonal rotation methods. Several criteria have been developed to determine the number of factors. The most popular are the Eigenvalue criterion and the scree plot (Sharma, 1996). To test the contribution of the variables in the formation of the factors, their loadings, which vary according to the sample size, were tested. Cronbach's alpha was used to assess the reliability of the questions. This index ranges from zero to one, with values greater than 0.7 being indicative of the high reliability of the questions. Following EFA, CFA was conducted to verify the items of the instrument. Model-fit measures were used to evaluate the model's overall goodness of fit (CMIN/df, CFI, TLI, SRMR, and RMSEA).

Afterward, five new variables were created by summarizing teachers' responses to analyze the data further for each factor. Descriptive statistics were calculated using the means and standard deviations. The normality of the data was tested with Shapiro-Wilk test and Kolmogorov-Smirnov test. Non-parametric tests (Mann-Whitney, Kruskal-Wallis) were used to compare multiple groups.

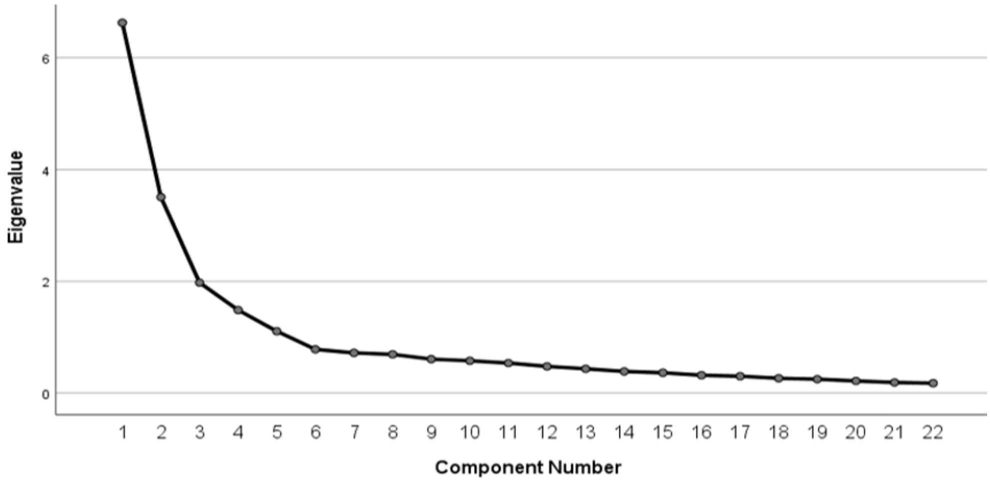

Figure 1. Scree plot (Source: Authors, using IBM SPSS)

RESULTS

Exploratory Factor Analysis Results

EFA results using PCA and oblique rotation criteria to simplify the identification of components was conducted. The value of KMO coefficient (0.841) and the result of Bartlett's test (χ^2[276]=2121.91, p<0.000) indicated the adequacy of the sample size chosen for our analysis. The factor structure that emerged from EFA confirmed the block-structure of the questionnaire. Two items with low charging and double high charging were removed. Factor analysis was performed again with the 22 items. The factors with eigenvalues greater than one were five. The scree plot also confirmed the same number of factors, evidencing a sudden drop in the scree as of the fifth factor (**Figure1**).

As shown in **Table 1**, four items for factor 1 represent experiments and emotions, five items for factor 2 represent value and usefulness of experiments, four items for factor 3 represent motivations to perform experiments, six items for factor 4 represent experiments and confidence and three items for factor 5 represent reasons for not performing experiments.

Table 1. Scales of attitudes

Attitudes	Loadings
Experiments & emotions	
1. I am fascinated by physics experiments.	0.812
2. Preparing and performing an experiment is a process that gives me pleasure.	0.785
3. I enjoy handling physics materials and instruments.	0.810
4. I feel pleasure every time I carry out an experiment.	0.771
Value & usefulness of experiments	
1. Students develop skills (handling materials, instruments, etc.) through experiments.	0.762
2. Experimentation promotes scientific thinking.	0.788
3. Experimentation helps students to appreciate and partly imitate the role of a scientist.	0.755
4. By using experiments, students develop critical thinking and critical thinking skills.	0.806
5. The experiment makes the theory seem more "real".	0.759
Motivations to perform experiments	
1. I attend/intend to attend seminars, trainings and conferences on experimental teaching of physics.	0.641
2. I refer to other sources, outside the textbook, to search for experiments for teaching physics.	0.828
3. To use new experiments in teaching physics, I gladly set aside a few hours of my free time to prepare.	0.757
4. I want to learn even more about physics experiments.	0.692
Experiments & confidence	
1. Every time I conduct an experiment, I am afraid it will fail.	0.737
2. When technical problems arise when conducting experiments, I am not able to guide my students to deal with them.	0.606
3. I am not very effective when I undertake with the students or alone the conduct (execution & supervision) of an experiment.	0.658
4. I wonder if I have the necessary skills to teach physics concepts through experiments.	0.769

Table 1 (Continued). Scales of attitudes

Attitudes	Loadings
5. I get frustrated when I think an experiment might fail.	0.799
6. I avoid using experiments that I find difficult to perform.	0.637
Reasons for not performing experiments	
1. Time available for teaching physics is an important reason I do not perform all necessary experiments.	0.726
2. Limited time I have due to personal, family, & other commitments contributes to omission of performing some experiments.	0.792
3. My increased responsibilities in the school unit are a reason for not performing some experiments.	0.830

Table 2. Cronbach's coefficients & percentages of variation of five scale factors

Factors	Items (n)	Cronbach's alpha reliability	Percentage interpreted by factors (%)
Value-usefulness	5	0.904	30.117
Confidence	6	0.861	15.420
Emotions	4	0.804	8.980
Motivations	4	0.828	6.749
Reasons	3	0.640	5.028

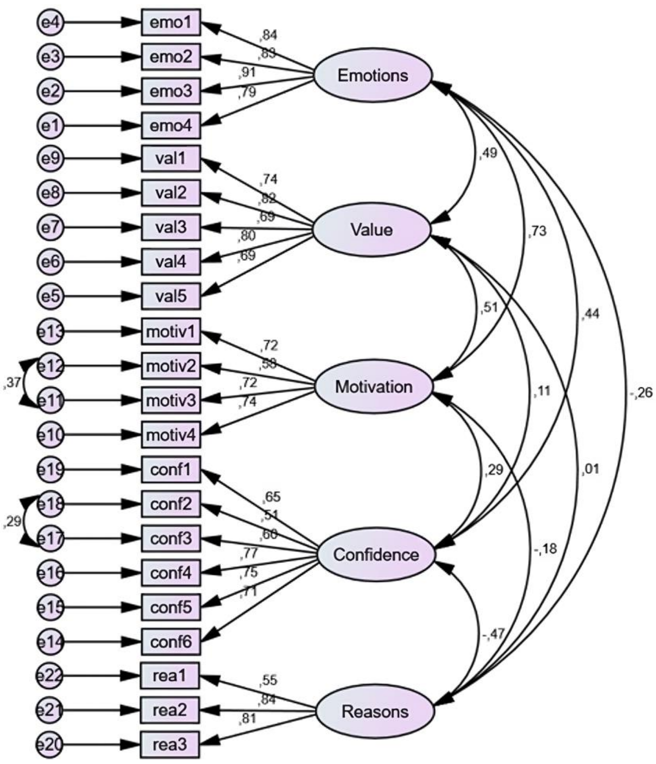

Figure 2. CFA (standardized estimates) (Source: Authors, using IBM SPSS Amos)

KMO measure confirmed the sampling adequacy for the analysis, KMO=.929. Bartlett's test of sphericity, $\chi^2(190)=10,731.3$, p<.000. This 22-item structure explained 66.82% of the variance in the pattern of relationships among the items. The percentages explained by each factor were 30.12% (value and usefulness of experiments), 15.94% (experiments and confidence), 8.98% (experiments and emotions), 6.75% (motivations to perform experiments), and 5.03% (reasons for not performing experiments).

Factor scales resulting from questions factor analysis, number of items that each factor embodies, Cronbach's alpha reliability coefficients and variance percentages explained by factors are shown in **Table 2**.

Confirmatory Factor Analysis

A CFA using AMOS 21.0 was conducted to test the five-factor instrument produced by EFA (**Figure 2**). CFA results and examination of the fit indices indicated that the model produced a good fit to data (Hu & Bentler, 1999; Steiger, 2007; Stylos et al., 2023a, 2023b). The factor model yielded a satisfactory fit for the data: CMIN/df=1.53, CFI=0.94, TLI=0.93, SRMR=0.07, and RMSEA=0.05.

Table 3. Means & standard deviation of scales

	Physics experiments & emotions	Value & usefulness of experiments	Motivations to perform experiments	Experiments & confidence	Reasons for not performing experiments
Mean	16.67	22.80	15.89	23.14	7.67
SD	3.24	2.65	3.25	5.06	3.14

Table 4. Mean & standard deviation of five attitudes scales relative to gender

	Mean-SD	
	Male	Female
Experiments & emotions	16.81-3.33	16.7-3.17
Value & usefulness of experiments	22.61-2.47	22.93-2.77
Motivations to perform experiments	16.03-3.23	15.80-3.28
Experiments & confidence	23.84-4.67	22.69-5.26
Reasons for not performing experiments	7.93-3.18	7.51-3.11

Note. *"Experiment & confidence" factor questions were negatively worded & variables were reversely coded (1-5, 2-4, 3=3, 4-2, & 5-1)

Table 5. Result of applying non-parametric Mann-Whitney test for five attitudes scales according to gender

	Physics experiments & emotions	Value & usefulness of experiments	Motivations to perform experiments	Experiments & confidence	Reasons for not performing experiments
U	3,521.000	3,424.000	3,643.500	3,309.500	3,522.000
z	-.780	-1.085	-.409	-1.405	-.772
p	0.436	0.278	0.683	0.160	0.440

Table 6. Mean & standard deviation of five scales of attitudes in relation to years of service

	Teaching years				
	1-5	6-10	11-15	16-20	21+
	Mean-SD				
Experiments & emotions	16.10-3.96	16.16-3.62	16.33-3.22	17.48-2.85	18.00-1.20
Value & usefulness of experiments	22.67-4.43	23.34-1.72	22.44-2.51	23.12-2.11	23.00-2.63
Motivations to perform experiments	15.38-3.10	15.31-3.59	15.87-3.49	16.32-2.64	16.68-2.41
Experiments & confidence	22.86-5.22	23.72-5.32	24.31-4.91	24.00-6.08	22.28-4.10
Reasons for not performing experiments	8.10-3.30	6.59-2.95	8.00-3.22	6.52-2.90	8.88-2.84

Descriptive Statistics

The mean scores and standard deviation (SD) are presented in **Table 3**. Four factors (physics experiments and emotions 16.67/20, value and usefulness of experiments 22.80/25, motivations to perform experiments 15.89/20, experiments and confidence 23.14/30) demonstrated high means scores while one factor (reasons for not performing experiments 7.67/15) presented moderate mean scores.

Differences in attitudes scales according to gender

A comparison of the means of the five scales of teachers' attitudes towards experimentation (experiment and emotions, value and usefulness of experiments, motivations to perform experiments, experiments and confidence, reasons for not performing experiments) with gender was performed (**Table 4**).

As all distributions were not normal, Mann-Whitney test was used to compare the mean responses. No significant difference was found (**Table 5**).

Statistical significance (p) test revealed no statistically significant differences in teachers' attitudes towards experiments in relation to gender.

Differences in attitudes scales according to years of service

The data on years of service deviated significantly from the normal. Kruskal-Wallis test revealed that there is a significant difference between the groups of the years of study with respect to the dependent variable "reasons for not performing experiments" ($\chi^2[4]=12.826$, $p=0.012$) (**Table 6** & **Table 7**).

Table 7. Result of applying non-parametric Kruskall-Wallis test for five scales of attitudes according to five groups of years of service

	Physics experiments & emotions	Value & usefulness of experiments	Motivations to perform experiments	Experiments & confidence	Reasons for not performing experiments
H	7.687	5.134	2.463	2.966	12.826
df	4	4	4	4	4
p	0.104	0.257	0.651	0.563	0.012

Table 8. Mean & standard deviation of five attitudes scales according to master's degrees holders & non-master's degrees holders

	Mean-SD	
	Holders	Non-holders
Experiments & emotions	17.32-2.83	15.90-3.52
Value & usefulness of experiments	22.90-3.02	22.70-2.16
Motivations to perform experiments	16.90-3.07	15.06-3.29
Experiments & confidence	24.11-5.02	22.00-4.89
Reasons for not performing experiments	7.08-3.21	8.37-2.90

Table 9. Result of applying non-parametric Mann-Whitney test for five attitudes scales to master's degree holders & non- master's degree holders

	Physics experiments & emotions	Value & usefulness of experiments	Motivations to perform experiments	Experiments & confidence	Reasons for not performing experiments
U	2,957.500	3,441.500	2,818.000	2,817.500	2,953.500
z	-2.887	-1.477	-3.282	-3.273	-2.882
p	0.004	0.140	0.001	0.001	0.004

Table 10. Mean & standard deviation of five attitude scales in relation to years of physics teaching

	Years of physics teaching		
	1-5	6-10	11-32
	Mean-SD		
Experiments & emotions	15.90-3.51	17.33-2.91	17.87-2.21
Value & usefulness of experiments	22.70-2.77	23.02-2.45	22.73-2.68
Motivations to perform experiments	14.89-3.58	16.98-2.55	17.03-2.21
Experiments & confidence	22.12-5.33	24.65-4.45	23.63-4.60
Reasons for not performing experiments	7.81-3.07	7.52-324	7.53-3.24

Differences in attitudes scales according to master's degrees

Four of the five factors found statistically significant differences in teachers' attitudes towards the experiments relative to whether or not they hold a master's degrees.

Specifically, differences are observed in the factors "experiment and emotions" (U=2957.500, z=-2.887, p=0.004), "motivation to perform experiments" (U=2818.000, z=-3.282, p=0.001), "experiment and confidence" (U=2817.500, z=-3.273, p=0.001) and "reasons for not performing experiments" (U=2953.500, z=-2.882, p=0.004) (**Table 8** & **Table 9**).

Differences in attitudes scales according to years of physics teaching

Statistically significant differences regarding teachers' attitudes towards experiments in relation to years of teaching physics were obtained from the use of Kruskall-Wallis's test. Specifically, differences are observed in factors "experiment and emotions" (χ^2[2]=11.619, p=0.003), "motivation-promotion to perform experiments" (χ^2[2]=16.442, p=0.000) and "experiment and confidence" (χ^2[2]=8.821, p=0.012) (**Table 10** & **Table 11**).

Differences in attitudes scales according to age groups

The data on years of service deviated significantly from the normal. Kruskal-Wallis test revealed that there is a significant difference between the teacher's age groups with respect to the dependent variable "Experiments and confidence" (χ^2[3]=8.752, p=0.000) (**Table 12** & **Table 13**).

Table 11. Result of applying non-parametric Kruskall-Wallis test for five attitudes scales according to three groups of years of physics teaching

	Physics experiments & emotions	Value & usefulness of experiments	Motivations to perform experiments	Experiments & confidence	Reasons for not performing experiments
H	11.619	.535	16.442	8.821	.544
df	2	2	2	2	2
p	0.03	0.765	0.000	0.012	0.762

Table 12. Mean & standard deviation of five attitude scales in relation to age groups

	Age groups			
	26-35	36-45	46-55	56+
	Mean-SD			
Experiments & emotions	16.4-3.17	16.78-3.27	16.96-2.87	17.21-4.15
Value & usefulness of experiments	23.01-1.96	22.71-2.52	23.26-2.16	21.29-5.65
Motivations to perform experiments	15.71-3.16	15.98-3.42	16.04-2.72	16.21-4.00
Experiments & confidence	22.78-5.26	24.29-4.84	21.52-4.67	22.64-4.91
Reasons for not performing experiments	7.77-3.20	7.13-3.17	8.48-2.78	8.29-3.07

Table 13. Result of applying non-parametric Kruskall-Wallis test for five attitudes scales according to four age groups

	Physics experiments & emotions	Value & usefulness of experiments	Motivations to perform experiments	Experiments & confidence	Reasons for not performing experiments
H	2.555	1.464	1.214	8.752	4.637
df	3	3	3	3	3
p	0.466	0.691	0.750	0.033	0.200

DISCUSSION

Initially, reliability and validity were examined using exploratory factor analysis, confirmatory factor analysis and Cronbach's alpha coefficient to verify the instrument's factor structure. The results confirmed the five-dimensional construct of the instrument and suggested acceptable α-coefficients.

Considering the mean scores of our questions, four of the five factors, "physics experiments and emotions, Value and usefulness of experiments, motivations to perform experiments, experiments and confidence", were observed with high mean scores. The factor "reasons for not performing experiments appears to have a medium score.

Primary school teachers' attitudes towards experimentation in teaching physics were not found to be statistically significant according to gender. Other research also supports this conclusion (van Aalderen-Smeets & van der Molen, 2013; van Aalderen-Smeets et al., 2017). On the contrary, according to "reasons for not performing experiments," we found statistical significance in our participants. Specifically, teachers with six-10 and 16-20 years of service are less influenced by external factors to perform experiments than the other groups of years of service). Also, the mean scores are higher in group six-10 than the group one-five, contrary to (Yildiz et al., 2006), who show that teachers with an experience of one-five years had better attitudes to experiments compared to those with an experience of 6-10 years.

The primary school teachers' attitudes towards experimentation in teaching physics were examined in terms of years of physics teaching, "experiments and emotions", "motivations to perform experiments and "experiments and confidence" were statistically different among the three groups. Although teachers who have taught the subject for more years have more positive feelings about it, are more motivated and feel more confident in performing experiments (the more years of teaching physics the higher the scores with statistical significance), probably burn-out syndrome could play a role (Kamtsios & Lolis, 2016) for the fact that teachers with the most years of teaching physics have lower confidence to perform experiments than the previous age group.

According to the age groups, we found a statistically significant difference in the field of confidence. The age group 36-45 feels more confident in performing experiments than the other age groups. This is likely since teachers in this age group have taught physics for more years.

Furthermore, the master's degree holders had statistically significant higher scores regarding "experiments and emotions", "motivation to perform experiments", and "experiments and confidence" and are less influenced by external factors to perform them compared to the non-master's degree holders. To the best of our knowledge, primary school teachers' possession or not of a master's degree and its relation to their attitudes towards using experiments in physics has not been studied. The teacher's field of study likely plays an important role in their attitudes towards experiments, as there is clearly a more positive attitude of those who hold a master's degree than those who do not. Studies in science teaching have shown that science teachers who have master's degrees were assumed to have better knowledge and attitudes than teachers who have bachelor's degrees (Wahono & Chang, 2019). So,

> "teachers with a master's degree have a higher level of education, which means that knowledge of educational innovations is more likely than those who only have a bachelor's degree" (Wahono & Chang, 2019, p. 13).

CONCLUSIONS

We conclude that primary school teachers' attitudes towards physics experiments vary according to years of service, their educational background and years of teaching physics. However, further investigation is needed to clarify these issues and improve the development and teaching of physics experimentation delivery in primary school teachers.

Study Limitations & Future Research Directions

A number of study limitations and future directions are worth mentioning. The sample does not represent the general population. However, important conclusions were drawn. The instrument could also explore another component: beliefs about gender differences in science. Further research is needed to collect more data through interviews. Also, additional research can be done with the same instrument for teachers who have not taught physics yet.

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Declaration of interest: The authors declared no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

REFERENCES

Andersen, H. K., Mayer, J., Hornung, G., & Thyssen, C. (2019). Attitude-behavior relations in teaching natural science. Results from a longitudinal study using the theory of planned behavior. *SocArXiv*. https://doi.org/10.31235/osf.io/dntw2

Ates, O., & Eryilmaz, A. (2011). Effectiveness of hands-on and minds-on activities on students' achievement and attitudes towards physics. *Asia-Pacific Forum on Science Learning and Teaching, 12*(1), 6.

Chiaverina, C., & Vollmer, M. (2005). *Learning physics from the experiments*. https://www.semanticscholar.org/paper/Learning-physics-from-the-experiments-Chiaverina-Vollmer/24e2fdf15ec1981931489422052ab1630ee5ee18

Denessen, E., Vos, N., Hasselman, F., & Louws, M. (2015). The relationship between primary school teacher and student attitudes towards science and technology. *Education Research International, 2015*, 534690. https://doi.org/10.1155/2015/534690

Duit, R., & Confrey, J. (1996*).* Reorganizing the curriculum and teaching to improve learning in science and mathematics. In D. F. Treagust, R. Duit, & B. J. Fraser (Eds.), *Improving teaching and learning in science and mathematics* (pp. 79-93). Teachers College Press.

Franklin, A., & Perovic, S. (2021). Experiment in physics. In E. N. Zalta (Ed.), *The Stanford encyclopedia of philosophy*.

Goodrum, D., Hackling, M., & Rennie, L. (2001). *The status and quality of teaching and learning of science in Australian schools*. https://catalogue.nla.gov.au/catalog/879767

Gott, R., &Duggan, S. (1996). Practical work: Its role in the understanding of evidence in science. *International Journal of Science Education, 18*(7), 791-806. https://doi.org/10.1080/0950069960180705

Guneşş, T., Dilek, N. S., Celikoglu, M., & Demir, E. S. (2011). The using levels of the teaching methods and techniques by teachers. *Procedia-Social and Behavioral Sciences, 15,* 1092-1096. https://doi.org/10.1016/j.sbspro.2011.03.244

Haagen-Schützenhöfer, C., & Joham, B. (2018). Professionalizing physics teachers in doing experimental work. *Center for Educational Policy Studies Journal, 8*(1), 9-34. https://doi.org/10.26529/cepsj.333

Hodson, D. (1996). Laboratory work as scientific method: Three decades of confusion and distortion. *Journal of Curriculum Studies, 28*, 115-135. https://doi.org/10.1080/0022027980280201

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1-55. https://doi.org/10.1080/10705519909540118

Jarvis, T., & Pell, A. (2004). Primary teachers' changing attitudes and cognition during a two-year science in-service program and their effect on pupils. *International Journal of Science Education, 26*, 1787-1811. https://doi.org/10.1080/0950069042000243763

Kamtsios, S., & Lolis, T. (2016). Investigating burnout in Greek teachers: Are there any teachers at risk? *Hellenic Journal of Psychology, 13*(3), 196-216.

Koponen, I. T., & Mäntylä, T. (2006). Generative role of experiments in physics and in teaching physics: A suggestion for epistemological reconstruction. *Science & Education, 15*, 31-54. https://doi.org/10.1007/s11191-005-3199-6

Lee, H. S., & Ryu, K. S. (2018). Relationship between the number of experimental classes, the science teaching efficacy belief, and the attitude toward science of physics-based science teachers. *New Physics: Sae Mulli, 68*, 1005-1014. https://doi.org/10.3938/NPSM.68.1005

Lumpe, A. T., Czerniak, C. M., Haney, J. J., & Beltyukova, S. (2012). Beliefs about teaching science: The relationship between elementary teachers' participation in professional development and student achievement. *International Journal of Science Education, 34*, 153-166. https://doi.org/10.1080/09500693.2010.551222

McDonald, C.V., Klieve, H., & Kanasa, H. (2019). Exploring Australian preservice primary teachers' attitudes toward teaching science using the *dimensions of attitude toward science* (DAS). *Research in Science Education, 51*, 1325-1348. https://doi.org/10.1007/s11165-019-09910-z

McLeod, S. (2012). *Experimental method. Simple psychology*. https://www.simplypsychology.org/experimental-method.html

National Research Council. (2012). *A framework for K-12 science education: Practices, cross cutting concepts, and core ideas*. National Academies Press.

Olsen, T. P., Hewson, P. W., & Lyons, L. (1996). Preordained science and student autonomy: The nature of laboratory task in physics classroom. *International Journal of Science Education, 18*(7), 775-789. https://doi.org/10.1080/0950069960180704

Osborne, J., & Dillon, J. (2008*). Science education in Europe: Critical reflections: A report to the Nuffield Foundation*. Nuffield Foundation.

Osborne, J., Simon, S., & Collins, S. (2003). Attitude towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049-1079. https://doi.org/10.1080/0950069960180704

Ozkal, K., Tekkaya, C., Sungur, S., Cakiroglu, J., & Cakiroglu, E. (2010). Elementary students' scientific epistemological beliefs in relation to socio-economic status and gender. *Journal of Science Teacher Education, 21*(7), 873-885. https://doi.org/10.1007/s10972-009-9169-0

Riegle-Crumb, C., Morton, K., Moore, C., Chimonidou, A., & Kopp, S. (2015). Do inquiring minds have positive attitudes? The science education of preservice elementary teachers. *Science Education, 99*(5), 819-836. https://doi.org/10.1002/sce.21177

Steiger, J. H. (2007). Understanding the limitations of global fit assessment in structural equation modeling. *Personality and Individual Differences, 42*(5), 893-898. https://doi.org/10.1016/j.paid.2006.09.017

Stylos, G., Kamtsios, S., & Kotsis, K. T. (2023a). Assessment of Greek pre-service primary teachers' efficacy beliefs in physics teaching. *Journal of Science Teacher Education, 34*(1), 44-62. https://doi.org/10.1080/1046560X.2021.2023959

Stylos, G., Kotsis, K., & Mavridis, D. (2016). Anaptiksi kai aksiologisi enos ergaleiou gia ti metrisi ton staseon ton fititon stin aksiopoiisi ton peiramaton sti didaktiki praktiki [Development and evaluation of a tool to measure students' attitudes towards the use of experiments in teaching practice]. In *Proceedings of the Panhellenic Conference on Teaching Lectures and Experimental Teaching in Natural Sciences* (pp. 523-531).

Stylos, G**.**, Siarka, O., & Kotsis, K. T. (2023b). Assessing Greek pre-service primary teachers' scientific literacy. *European Journal of Science and Mathematics Education, 11*(2), 271-282. https://doi.org/10.30935/scimath/12637

Sunbul, M., Afyon, A., Yagiz, D., & Aslan, O. (2004). The predicting the academic success, effect of learning strategy, style and attitudes of students in the predicting the academic success in the science lessons in primary 2 stage. In *Proceedings of the 12th National Congress of Education Sciences* (pp. 1573-1588).

van Aalderen-Smeets, S. I., & van der Molen, W. J. H. (2013). Investigating and stimulating primary teachers' attitudes towards science: Summary of a large-scale research project. *Frontline Learning Research, 1(2),* 3-11. https://doi.org/10.14786/flr.v1i2.27

van Aalderen-Smeets, S. I., van der Molen, W. J. H., van Hest, E. G. W. C. M., & Poortman, C. (2017). Primary teachers conducting inquiry projects: Effects on attitudes towards teaching science and conducting inquiry. *International Journal of Science Education, 39*(2), 238-256. https://doi.org/10.1080/09500693.2016.1277280

van Aalderen-Smeets, S. I., van der Molen, W. J.H., & Asma, L. J. F. (2012). Primary teachers' attitudes toward science: A new theoretical framework. *Science Education, 96*, 158-182. https://doi.org/10.1002/sce.2046

Wahono, B., & Chang, C.-Y. (2019). Assessing teacher's attitude, knowledge, and application (AKA) on STEM: An effort to foster the sustainable development of STEM education. *Sustainability, 11*(4), 950. https://doi.org/10.3390/su11040950

Yesilyurt, M. (2004). Student teachers' attitudes about basic physics laboratory. *Turkish Online Journal of Educational Technology, 3*(4), 49-57.

Yildiz, E., Akpinar, E., Aydogdu, B., & Ergin, O. (2006). Science teachers' attitudes towards aims of the science experiments. *Journal of Turkish Science Education, 3*(2), 2-18.