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Experimentation anxieties of pre-school and primary school teacher candidates

Engin Baysen
Department of Classroom Teaching, Ataturk Faculty of Education, Near East University, Nicosia, Cyprus
engin.baysen@neu.edu.tr
Fatma Baysen
Independent Researcher

Experimentation is widely accepted as being central to science education. However, anxiety about experimentation often prevents its use. While a considerable number of studies on anxiety related to laboratory experimentation have been conducted, studies on in-class experimentation is limited. In the research study reported on here we explored the anxiety about in-class experimentation of teachers as enacted in pre-school and primary school (PP) education. We also searched for possible similarities in the anxiety of the pre-school and primary school teacher candidate (TC) cohorts to explain the persistence of their anxiety. TCs responded to an open-ended question through a qualitative analysis procedure. The levels of anxiety were classified into three categories: low, moderate, and high. The time when the TCs experienced the anxiety was classified into 3 other categories: backstage, stage, and finale, which were coupled with the levels of anxiety. Quantitative analysis showed that there was a high similarity between the two cohorts of TCs' experimentation anxieties. We conclude that teacher candidates' future students would encounter a continuous, uninterrupted, unfavourable anxiety-filled environment with regard to experiments throughout their PP.

Keywords: anxiety; experimentation; pre-school; primary school; teacher candidates

Introduction

Experimentation is a method of inquiry that students should develop from the early years of pre-school and primary school (PP) education (Gutierrez, Cruz-Guzmán & Rodríguez-Marín, 2019). Experimentation is accepted as an important modality of teaching science (Docherty-Skippen, Karrow & Ahmed, 2020). Although a considerable amount of previous research argues against experimentation, for example, the cognitive load theory (Naude & Meier, 2019; Zhang, 2019), it is still a trusted teaching method in all formal education levels and scientific subjects. Experimentation holds many benefits. Some of these include developing observation, material manipulation, and communication skills. Moreover, experimentation increases one's knowledge of the environment, precise rules, and principles. It also increases self-efficacy in learning. Research has shown favourable attitudes toward the use of experiments in teaching. Teachers regard experimentation as the correct way to teach science. It is also a method that most students love (Nielsen, 2012). The need to experiment has become a cliché: a science course without experiments would be fruitless. Schools are equipped with experimentation materials and advocate cheap, straightforward, and easy-to-obtain apparatus (Yükseköğretim Kurulu, n.d.). Historically, the focus on experimentation has always existed; it is regarded as the primary key to engaging students in learning and increasing the number of students choosing to take science subjects. Recent science, technology, engineering, and mathematics (STEM) studies have opened a new perspective on experimentation by integrating STEM to solve problems. Thus, we regard the role of experimentation to be critical (Millî Eğitim Bakanlığı, 2018; Millî Eğitim Bakanlığı Eğitim Genel Müdürlüğü, 2013; Soares, De Campos, Thomaz, Da Cruz Pereira & Roehrs, 2016).

Regardless, stakeholders continue to complain about the limited numbers of students who choose science-related subjects and professions, and teachers who prefer not to use experiments in teaching. In our study we focused on the latter problem. Why don't PP teachers use experimentation as expected? Not conducting experiments in PP science classes is a critical problem. The reasoning behind this averse reaction to experiments includes inefficacy in coping with anxieties (Pendergast, Lieberman-Betz & Vail, 2017).

A great deal of research has considered the issue of anxiety in the teaching of science. However, few studies only considered experiments as the cause of anxiety. Literature either includes experimentation as a part of science anxiety creation (Bryant, Kastrup, Udo, Hislop, Shefner & Mallow, 2013) or focuses on laboratory issues (Alkan & Erdem, 2013) and assesses problems with laboratory equipment, student engagement and whether teachers can use the laboratory efficiently or not. Thus, most research addresses secondary and upper grades but not PP education. However, PP teachers mostly use experiments in the class instead of in laboratories. They either do experiments in class or tell their students to do so. PP teachers either perform demonstration experiments or let their students conduct simple experiments (Çepni & Ayvacı, 2015:292–294).

With this study we aimed to address this gap in the literature by attempting to elucidate the issue at the PP education level. There is a need to understand the context of PP education to produce more systematic and methodologic discussions and suggestions. Thus, it is necessary to gain deeper insight into PP teacher candidates' (TCs) experimentation anxiety before designing a teacher training programme. Instead of adopting the findings of laboratory anxiety and findings of higher education levels to the PP education level, there is a need to assess the context of experimentation in PP education only to conduct a more appropriate discussion. Expecting of TCs

to solve their anxiety-related problems themselves seems unrealistic. Moreover, experienced teachers can increase new teachers' anxiety (Shemwell, Avargil & Capps, 2015). Thus, teacher trainers do not have the luxury of ignoring the anxiety issue. Teacher trainers should do their best to prevent the development of anxiety in TCs. They should also alleviate this anxiety if it already exists. Furthermore, depending on the science curriculum, TCs and pupils should be fond of inquiry-based science and experimentation. Teachers should have a positive attitude toward experiments; at least, their anxiety should not be so high that it prevents them from using experiments in their teaching. Additionally, they should not transfer their anxiety to their students. In our study we focused on the experiment-related anxiety of PP education teachers. The study benefits teachers, TCs and teacher trainers.

Background

Anxiety

Researchers have attempted to enlighten readers on the phenomenon of anxiety. Anxiety is inevitable, and it originates from threats or perceived threats (Downing & Filer, 1999; Jones, Hobbs, Kenny, Campbell, Chittleborough, Gilbert, Herbert & Redman, 2016). Fear of the unknown and of failure and a lack of information and skills can easily cause anxiety (Shen, 2008). Anxiety is mostly perceived as a problem. The level of deterioration depends on the experiences of anxiety (Bandura, 1989; Jasalavich, 1992); these experiences can cause burnout (Byrne, 1994), which leads to the loss of skills and can prevent effort and innovation (Shen, 2008). Being conservative prevents apprehension (Bonwell & Eison, 1991:57).

In addition, those experiencing anxiety can stop, decrease, or prevent trouble (Bandura, 1989). There are ways to prevent or eliminate the causes of anxiety (Alkan & Erdem, 2013; Bursal, 2012; Cox & Carpenter, 1989; Gilbert & Byers, 2017; Palmer, 2006). Bandura highlights that high self-efficacy can allow an individual to overcome or reduce anxiety (Bandura, 1989), which in turn leads to achievement (Zoller & Ben-Chaim, 1989). However, research has shown that anxiety persists in practice (Bandura, 1989; Kaplan, 1970; Yürük, 2011).

Teaching anxiety

Anxiety influences teaching environments; it creates problems for teachers and students (Beisel, 1991; Gilbert & Byers, 2017; Koran & Koran, 1981), and it also influences teaching strategies (Czerniak & Haney, 1998; Czerniak & Schriver, 1994; Keavney & Sinclair, 1978; Sinclair & Nicoll, 1980). Teachers with high anxiety, particularly new teachers, do not choose the teaching methods that they were taught in teacher training, but rather they choose the methods with which they feel most comfortable. Any attempt to change their methods may create anxiety, which is not welcomed by teachers nor their students (Bonwell & Eison, 1991; Woods, 1994). Teachers often choose the same method that their PP education schoolteachers chose or what is recommended by older teachers. Consequently, they choose teacher-centred approaches (Czerniak & Haney, 1998; Hodgin, 2014).

Research has shown that the causes of anxiety are related to different dimensions of the learning environment (Çelik, 2008). These dimensions include managing the class (Eksi & Yakışık, 2016), a lack of subject knowledge (Rice, 2005), undergoing personal evaluation (Morton, Vesco, Williams & Awender, 1997), having the skill to deal with unexpected cases (Alpan, Özer, Erdamar & Subaşı, 2014), and using time effectively (Nair & Ghanaguru, 2017).

Researchers have often included demographic variables in examining influences on anxiety. Morton et al. (1997) found that anxiety was culture-dependent. They found that there were similarities in the levels of anxiety in different countries. When individuals shared similar cultures, i.e., Canadian and British TCs often displayed similar anxieties. Student teachers' anxiety increase as they progress from early to later primary classes. Female teachers are more anxious than male teachers.

As in our study, researchers have sought to categorise anxiety in order to increase their comprehension thereof. Çelik (2008) categorised anxiety of preservice teachers of English as a foreign language (EFL). He categorised anxiety into the following six categories: personal, communication-centred, evaluation-based, external, lesson-preparation and teaching-related anxiety. He also categorised anxiety into three levels, namely, low, medium, and high.

Another categorisation concerns the progress from teacher candidate to teacher. Fuller and Bown (1975) were the pioneering researchers in creating stage theory for concern. According to Fuller and Bown, TCs' focus on anxiety changes over time. It develops along the route from teacher candidates becoming teachers. They note three types of concern, namely, "self-concern", "task concern", and "impact concern." Self-related anxiety may include the approval of other teachers, that of students, and that of other school-related individuals. Task-related concern includes class and time management. Impact concern includes meeting students' learning needs.

Many researchers agree with Fuller's stage development theory (Beeth & Adadan, 2006; Conway & Clark, 2003; Malderez, Hobson, Tracey & Kerr, 2007; Pyper, 2009; Van den Berg, Sleegers & Geijsel, 2001). Others are of the opinion that the stage and chronological approaches to teacher concerns are not valid (Capel, 2001; Evans & Tribble, 1986; Rogan, Borich & Taylor, 1992).

According to these studies, different anxieties can exist at the same time.

Teacher anxiety is correlated with student anxiety (Beilock, Gunderson, Ramirez & Levine, 2010; Doyal & Forsyth, 1973). This consequence is the most damaging as it shows that anxiety can be transferred to students, which has a snowball effect and adds to the status quo.

Science and experimentation anxiety

Most research views teachers' knowledge, self-efficacy beliefs and anxiety towards science, inquiry, and laboratory use as important because these issues may create obstacles in science education (Harlen & Holroyd, 1997; Hodson, 1993; Jarvis & Pell, 2004; Karakaya, Avgın & Kumperli, 2016; Osborne, Simon & Collins, 2003; Van Driel, Beijaard & Verloop, 2001). Research states that there is a negative correlation between the level of anxiety related to teaching science and self-efficacy (Yürük, 2011). Teachers are expected to reserve more time for science activities and thereby benefit from it (Czerniak & Lumpe, 1996; Westerback & Long, 1990). Theoretically, increasing the time spent on teaching science would increase the experimentation time. Nevertheless, research has shown that teachers spend less time on science than on other subjects (Blank, 2013; Brand & Wilkins, 2007; Fulp, 2002; Roychoundhury, 1994).

Recognising the lack of the use of experimentation, researchers have tested different approaches to decrease their anxiety about science and experimentation. For example, Palmer (2006) used primary science methods and, more recently, Ural (2016) used a guided inquiry laboratory approach with third-year, undergraduate science education students as an intervention. Both authors found a decrease in anxiety. Although the researchers used the idea that occupying students with first-hand experimentation activities would prevent experimentation anxiety, a lack of research about the PP education context still exists.

Purpose

To improve science teaching, the first step in diminishing the effect of anxiety or preventing the causes of anxiety is to understand the nature thereof. Exploring their origins and the interrelations among the causes of anxiety is essential. For example, we examined how TCs experience anxiety, how they transfer it to others, the reasons behind the persistence of anxiety and how anxiety influences TCs' science teaching. Thus, we aimed to discover more in-depth information about the anxiety related to experiments. We attempted to answer the following questions:

1) How can experiment-related anxiety be categorised depending on
   a) its levels of influence and
   b) the time it is experienced?
2) Is there any relation between the levels of anxiety and the time that TCs experience it?
3) Is there any relation between the types and levels of anxiety of the two cohorts of TCs?

Methods

The research study reported on here was based on mixed methods research (Teddlie & Tashakkori, 2009:7). A qualitative research method was adopted. Qualitative research seeks to reveal in-depth information about a particular group of people. The categories that emerged were quantified to reveal the differences (if any) between the two groups of TCs (Chi, 1997). The first two research questions were answered using qualitative research procedures. Parts 3A (types) and 3B (levels) of the last question depended on statistical procedures based on quantitative research.

Participants

One hundred and ten pre-school (n = 68) and primary school (n = 42) Turkish TCs participated in the study. Thus, two different cohorts of TCs were included in the study to answer the third research question, with which we tried to reveal a predictor for the persistence of anxiety. The pre-school cohort included 62 female and six male TCs. The primary school cohort comprised 32 female and 10 male TCs. The TCs came from different parts of Turkey, but mainly the eastern and south-eastern geographical regions. The participating TCs were 20 or 21 years old. Both of these cohorts of TCs would teach science-related subjects during their careers. Generally, TCs should prepare their students in a way that is compatible with the standards of upcoming grade levels. Those standards depend on constructivist approaches. Constructivist approaches accept inquiry and experimentation as cornerstones. The participating pre-school TCs were in their fifth semester while the primary school TCs were in their third semester of the training programmes that comprised a total of eight semesters. Both TC groups were students at the same university. The pre-school TCs were enrolled for the Pre-school Science Education course while the primary school TCs were enrolled for the Science and Technology Laboratory course.

Data Collection and Ethical Issues

The data were collected during the 2018–2019 fall semester at one of the private universities in northern Cyprus where Turkish is spoken and accepted as a teaching language. The data were collected at the beginning of the semester in ordinary classes. Each TC responded to her/his question individually within a predetermined time. TCs used one class period to answer the question. The lessons continued normally after all the TCs had responded. The same open-ended question was posed to both TC cohorts: "What are your concerns about utilising experiments in your teaching? Explain your answer based on your experiences." The question was presented on a blank page, and the TCs could use extra pages if required. One of the researchers was present in the class while

the students were responding. He answered questions when they were raised and checked the submitted answers for possible misunderstanding. Only a few responses were returned to the students to add more detail.

The researchers explained the aim of the study and the importance of the study for the TC's future education. The students who participated in the study participated voluntarily and their consent for participation was obtained from them. The TCs were informed that their responses would be used for scientific reasons only and that the responses would remain anonymous. Furthermore, they were informed that they could withdraw from the study at any time during the research process and that their responses would then be excluded from the study (Creswell, 2012:592).

Data Analysis

The data analysis was carried out using qualitative research analysis methods (Creswell, 2012:236–264; Marton & Booth, 1997:132–136). The analysis included five steps.

- Both researchers prepared the data and repeatedly read the answers to take note of the experiment-related anxiety among the TCs.
- The two researchers read the data a number of times more times to determine the dimensions (level and timing of anxiety) that depended on the most common responses stated by the participants. These would be the focus of researchers and readers worldwide and would be beneficial for studies on science anxiety. Ideas that the TCs seldom mentioned were omitted. The list of coding dimensions appears in Appendix A.
- The two researchers together read the code list many times to assign categories to the dimensions that were clearly different from each other, had logical relations with each another, and of which there were only a few (Marton & Booth, 1997:124–125).
- An independent researcher experienced in qualitative research was asked to perform the coding for inter-rater reliability (Creswell, 2012:161). The analysis was finalised only after an acceptable ratio had been reached. The inter-rater reliability was calculated using Holsti's method (Neuendorf, 2002:167–190). The formula is as follows: PAo= 2A/(nA+nB), where PAo is the proportion agreement observed, A is the number of agreements between the two coders, and nA and nB are the numbers of units coded by coders A (researchers in this study) and B (independent researcher). Because the numbers of units coded by the coders were equal at 20 and the number of agreements between the coders was 19 for the levels of anxiety and 20 for the timing, the PAos were 0.95 and 1.00, respectively. Thus, the PAos (> 0.80) were highly acceptable.

Descriptive and inferential analysis methods were used in the quantitative part of the study. The analysis included frequencies, percentages, and chi-square calculations. The Statistical Package for the Social Sciences (SPSS) 21 was used for chi-square calculations.

Results

TCs stated different kinds of experiment anxiety, which were all generated in secondary and high school classes. TCs put forward two dimensions in their responses to the open-ended question, namely, the level of anxiety and the time at which this particular anxiety was prominently experienced. TCs talked about different interference levels of experiment anxiety. Anxiety interferes with one's functioning when experimenting. That is, the more severe the anxiety, the more likely it is that the anxiety will interfere with the teachers' willingness to follow through on experimentation in the classroom.

The levels of anxiety were not predetermined but deducted from the TCs' responses in that the TC's responses included some indication of their anxiety levels. For example, "*I should practice many times to ensure that I am not unsuccessful*" was categorised as low anxiety because the interference level was lower than in the following two examples. "*If I recognise that my preparation was not fruitful (low anxiety) and I could not reach scientific results (moderate anxiety), then the problem is big!*" indicates that the anxiety is greater than that in the previous example. "*I cannot bear hurting my students. It is better to not do experiments*" was categorised as high anxiety. Three categories of anxiety levels thus emerged: low, moderate, and high (see Appendix A).

We also considered the time when the TCs had experienced the particular anxiety. The time dimension had a chronological logic. The time of the anxiety was not predetermined but rather deducted from the TC's responses. The anxiety started from the moment that a TC decided to perform an experiment, continued while the experiment was being conducted, and ended at the final moment when the experiment ended. We named these time intervals the backstage, stage, and finale, respectively. For example, we categorised "*a lack of subject knowledge*" as being backstage anxiety because the TCs stated that they experienced this feeling before the experiment.

The time dimension was found to accompany the level of anxiety (see Figure 1). Three links were thus formed. Low anxiety was linked to backstage, moderate anxiety was linked to stage, and high anxiety was linked to finale. It was evident that there was an increase in the level of anxiety from backstage through stage to the finale.

In the following section we present more detailed findings including the categories for the dimensions, the characteristics of the categories, and the relations between the categories, explaining how the categories were interrelated and decided upon.

Low Anxiety (L)

The low anxiety category included encountering problems caused by a lack of certain aspects that were required for using experiments in science teaching.

These aspects (drawbacks) were knowledge, skills, experience, expert support, preparation, and exercise, where knowledge included knowledge of the materials, knowledge of the learners, and knowledge of the experiment. Low anxiety was matched by the backstage period, and it was about predictable, manageable, and preventable situations. TCs can resolve this level of anxiety beforehand through a particular amount of study, experience, and attention. These anxieties did not cause critical danger but rather lead to a dreadful start. This category of concern did not stop teacher candidates from using experiments. Thus, this category represented a challenging situation but still indicated a positive mental state.

Moderate Anxiety (M)

This category was about making mistakes during the experiment and included many concerns (see Appendix A). The stage period matched this level of anxiety. Overall, moderate anxiety comprised uncertainty about experimenting. Thus, these anxieties may ruin the experiment and cause non-scientific results. Again, these consequences were not vital. However, they were more critical than those included in the preceding category. This category represented a challenging and semi-pessimistic state of mind. Moderate anxiety may be coupled with other low anxiety issues and emerge as a more significant problem. Additionally, these may create a pessimistic mood resulting in TCs giving up on using experiments in their teaching. One TC stated: "*If I recognise that my preparation was not fruitful (low anxiety) and I could not reach scientific results (moderate anxiety), then the problem is big!*"

High Anxiety (H)

High anxiety included the risk of hurting others and facing humiliation, and these issues were based on critical dangers during experiments. For example, one TC, talking about her secondary, school stated: "*What if the mixture explodes?*"

This rationale stemmed from experience. One TC stated: "*While experimenting, I heated the tube; it exploded and I was afraid*." Another TC emphasised the event by sharing the following anecdote: "*My teacher in secondary school lost one of his fingers while experimenting*."

The high anxiety level represented the ultimate fear of the experiment. It was the final uncontrollable phase of the experiment. This level could end any experiment or experimenting as a teaching approach, which caused TCs to refrain from doing future experiments. One of the TCs said: "*Since then* (secondary school), *I did not even intend to experiment.*" This category included a total pessimistic character. The TCs in this category confessed that they would not use experiments in their classes since they could not handle being responsible for their students: "*I cannot bear hurting my students. It is better to not do experiments; I can teach them using other methods instead*."

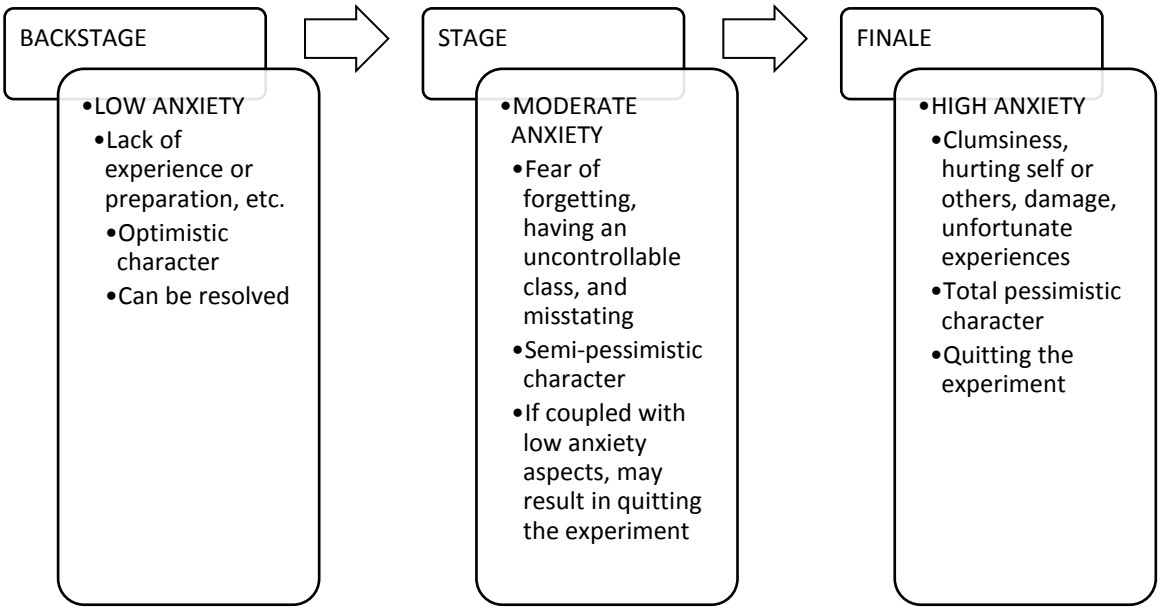

Figure 1 Levels, timing, and features of anxiety

Only three TCs (one from pre-school and two from primary school) did not show any anxiety (see Table 1). Thus, almost all TCs showed anxiety with regard to using experiments in teaching. Nearly half

of the TCs had a high level of anxiety. Approximately 80% of TCs had multiple levels (two or three) of concern.

The issue of a lack of expert support was noted in the pre-school (f = 5) group but not in the primary group; it was categorised as a low level of anxiety. Only five pre-school TCs noted the issue of "*managing the class*", and it was categorised as a moderate level of anxiety. Moreover, only one primary school TC noted the issue of "*patience*." No particular high-level anxiety was detected in only one group. The results did not show a significant difference between the two cohorts. Thus, there was a need to quantify the data and conduct an inferential analysis.

Table 1 Frequency levels of anxieties

	0	L	M	H	L+M	L+H	M+H	L+M+H	Total
Pre-school	1	2	5	1	23	2	12	22	68
Primary school	2	2	6	2	11	9	3	7	42
Total	3	4	11	3	34	11	15	29	110
Percentage (%)	3	4	10	3	31	10	14	26	100

There was a significant difference between the number of TCs with experiment anxiety (f = 107) and those without experiment anxiety (f = 3). A chi-square test delivered no significant difference between the number of TCs who had high anxiety (f = 58) and those who did not (f = 52), χ^2 (1, N = 110) = .327, p > .05. Moreover, there was no significant difference between the two cohorts, χ^2 (1, N = 110) = .203, p > .05. Finally, the gender variable did not result in any significant difference either, χ^2 (1, N = 110) = 98.327, p > .05.

Discussion

In this section we discuss the findings of our research, state the implications for science teaching and education in general, indicate its contribution to theory, and make suggestions for future research. By assessing TCs' anxiety, we hope that teacher trainers, TCs, teachers, and researchers benefit from this study.

The dimensions of categories of anxieties revealed in the study will benefit teacher trainers and teachers in general. The teacher trainers and teachers need to understand the types of anxiety that their students experience in order to define the problem and act accordingly. For example, if the anxiety is related to backstage, then teacher trainers can understand that the anxiety is related to a lack of preparation for the experiment, and that the TC did not appropriately practice the experiment. In addition, if it is about the finale and fear of humiliation (Dweck & Leggett, 1988), the teacher trainer can create an atmosphere of acceptance for the TC to gain "social success" (Kaplan, 1970:75). Moreover, teacher trainers should not underestimate the cases of low and moderate anxiety; they should pay attention and prevent their co-occurrence since the combination may increase the perceived threat.

The different levels of experiment-related anxiety, particularly the three categories raised, were consistent with the literature findings on science teaching (Çelik, 2008). TCs had experiences that influenced their attitudes about experiments. These experiences accumulated to create a hopeless situation. This outcome is a type of "learned helplessness." The result is that their experiment experiences could prevent TCs from conducting future experiments (Dweck & Leggett, 1988; Hayes, Wilson, Gifford, Follette & Strosahl, 1996; Raufelder, Regner & Wood, 2018).

Lazarus (1991) state that people may react to anxious situations in three ways. The first is avoidance, the second is to remain in the situation but to increase one's vigilance, and the last is to eliminate the source of the threat. In the high-anxiety situation about the use of experiments, teacher trainers should suggest the second and third responses, as the worst choice for the TCs in our study was to avoid or not do experiments at all.

An attempt at experiments during teaching could spark multiple and different types of anxiety. If a TC overcomes any one type of anxiety, another type of anxiety may appear. Other than the level of anxiety, the persistence of experiment-related anxiety also had a disturbing effect, which resulted in teachers refraining from experimenting in their careers. One TC clearly stated: "*Let's say I prepared well … gathered the right materials for the experiment. Then, what if a student had an accident? I cannot control them all.*"

There was no significant difference between the two cohorts of TCs, which supports the findings of culture dependency (Morton et al., 1997). Moreover, there was no significant difference between the two cohorts with regard to gender as a variable, which is consistent with the findings of Karakaya et al. (2016). If TC exhibit experiment anxiety once they start teaching, this anxiety may be transferred to their students, resulting in the transfer and continuation of anxiety with regard to experimentation.

One important finding of this study is that TCs stated that the experiences that caused their anxiety took place in secondary and high school, but not in the pre-school or primary school. Teacher trainers should ensure that TCs understand that the goals of pre-school and primary school teachers differ from those of secondary and high school teachers. PP education requires more fundamental skills, knowledge, and materials. Thus, these teachers would need more straightforward, manageable, and less

dangerous experiments, and there would be no need to fear PP education experiments.

Many studies (Boz, 2008; Capel, 2001; Fuller & Brown, 1975; Matoti & Lekhu, 2016) indicate that class management is a cause of anxiety. However, this was not evident from the responses in our study.

The findings regarding features of experimentation anxieties in our study contribute to the Theory of Inquiry (Cox & Carpenter, 1989) in science teaching, particularly in a teacher training context, as experiments are at the heart of inquiry. Experimentation anxieties

- interfere in varying degrees
- originate in context (in secondary and high school) but can still influence other situations (in PP)
- feed each other and create a bigger issue
- increase as the stage approaches
- are culturally dependent and thus persist.

Although challenges regarding the teaching of science in primary schools in the South African context exist (James, Beni & Stears, 2019), there is a lack of research dealing with science anxiety. For example, Matoti and Lekhu (2016) dealt with pre-service teachers' sources of anxiety in a general sense and stated that classroom management was regarded as an anxious experience. We hope that our study will result in researchers focusing on anxiety and anxiety in the teaching of science in South Africa and similar contexts in order to solve problems related to anxiety in teaching.

In our study we dealt with pre-school and primary school TCs, which enabled us to contrast their respective levels of anxiety – one of the strengths of the study. We suggest that future research should be done on primary-secondary and secondary-higher TCs to make similar comparisons.

Conclusion

Most TCs experience experiment-related anxiety. Experiment-related anxiety depends on the level of the influence of the causes and their timing. The categories of low, moderate and high anxiety match the time periods of backstage, stage, and finale, respectively. Both the level and persistence of anxiety throughout secondary and high school harm one's general attitude towards experimenting. The combinations of different levels of anxieties result in a more complicated and difficult problem. The finale stage is the most critical because it keeps teachers from conducting experiments.

Authors' Contributions

The research was conceptualised by Engin Baysen and Fatma Baysen. Engin Baysen was responsible for the data collection. Engin Baysen and Fatma Baysen drafted, critically revised and finalised the article for publication.

Notes

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Appendix A: TCs' Anxieties

Code (threat)	Example	Pre-school *f*/%	Primary school *f*/%
	Low anxiety		
Lack of expert support	If I had someone with me who was an expert, then I would be confident to do an experiment.	0/0	5/12
Lack of subject knowledge	I should be knowledgeable about the subject.	21/31	10/24
Lack of skills	I do not have the skills to do the experiment.	3/4	1/2
Suitability of the materials	There should be enough materials required for the experiment, otherwise, the experiment might fail.	15/22	12/29
Lack of material knowledge	I do not have knowledge of the material and am afraid that would impact my experiments.	12/18	6/14
Lack of practice	I should practice many times to not be unsuccessful.	4/6	7/17
Lack of knowledge on experimenting	I know nothing about doing experiments.	5/7	2/5
Lack of knowledge of the learners	I have to know the learning properties of the students.	17/25	1/2
Lack of experience	I am anxious about the first time because I have not attempted to perform an experiment before.	8/12	2/5
Lack of preparation	If I do not do any preparation for an experiment, then I have to do it spontaneously.	6/9	1/2
Total		49/72	30/71
	Moderate anxiety		
Significant/Favourable finding	We need to reach a significant and scientific finding; otherwise, our experiment is **fruitless.**	14/21	11/26
Incorrect findings	I am afraid of finding incorrect results (contrary to the scientific results).	27/40	20/48
Stage anxiety	I am afraid of experimenting in front of people.	3/4	2/5
Environment	The environment should be suitable for doing an experiment.	2/3	3/7
Patience	The experiment requires patience; otherwise, you could get angry and act out, which would ruin the experiment.	0/0	1/2
Fear of forgetting, steps, etc.	I fear forgetting the steps that I should follow, particularly those that are critical.	19/28	5/12
Fear of misstating	I fear misstating something.	22/32	3/7
Timing	The time should be used efficiently, and the experiment should finish on time.	11/16	1/2
Excitement	Excitement can cause mistakes to be made while experimenting.	33/49	2/5
Managing the class	I fear losing class control while experimenting.	10/15	0/0
Total		61/90	28/67
	High anxiety		
Clumsiness, hurting self or others, damage, and unfortunate experiences	I fear being clumsy during an experiment, which may cause an accident, i.e., will I hurt myself? I am afraid of hurting others and damaging the things around me while experimenting, such as by causing explosions. My anxiety towards doing experiments started when I was a child. I tried to light a bulb in an electrical circuit. The bulb exploded.	29/43	20/48
Humiliation	I could ruin the experiment which might result in my humiliation.	16/24	2/5
Total		36/57	21/50