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Research Article

An Investigation of Science Teacher Candidates' Context-Based Question Writing Skills

Fen Bilimleri Öğretmen Adaylarının Bağlam Temelli Soru Yazma Becerilerinin İncelenmesi

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Abstract

Purpose: *Developments in education and teaching activities in the 21st century have transformed student roles, positioning students as individuals who critically evaluate, question knowledge, and apply it in daily life and problem-solving. The PISA exam, which assesses skills in various domains, stands out in determining whether students have acquired these competencies. Teachers play a crucial role in providing students with opportunities to gain these skills and in evaluating their progress. The first step in achieving the targeted educational standards is the training of teacher candidates. Therefore, equipping teacher candidates with the ability to create context-based texts and formulate questions appropriate to the context is of great importance. Based on this premise, this study aims to thoroughly examine the context-based question-writing skills of science teacher candidates.* ***Method:*** *The study was conducted using a case study design, one of the qualitative research methods. The participants consisted of 34 science teacher candidates. The study was conducted in the "Critical and Analytical Thinking" course conducted by the researcher. The science teacher candidates taking this course created context-based texts on topics of their choice and prepared seven questions for each PISA scientific literacy level based on their texts. The content of the context-based texts and the questions prepared by the teacher candidates constitute the research data. The research data were analyzed using descriptive analysis, one of the qualitative data analysis methods. During the data analysis process, different researchers conducted analyses, and consistency was ensured.* ***Findings:*** *The findings revealed that the context-based questions prepared by science teacher candidates were moderately aligned with the targeted PISA scientific literacy levels.* ***Conclusion:*** *As a result of the research, it was suggested that science teacher candidates' context-based question-writing skills could be further developed through training during their undergraduate education and through question-writing activities conducted under the supervision of subject matter experts.*

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Özet

Amaç: *21. yüzyılda eğitim ve öğretim faaliyetlerindeki gelişmeler, öğrenci rollerini dönüştürmüş, öğrencileri bilgiyi eleştirel olarak değerlendiren, sorgulayan ve günlük yaşamda ve problem çözmede uygulayan bireyler olarak konumlandırmıştır. Çeşitli alanlardaki becerileri ölçen PISA sınavı, öğrencilerin bu yeterlilikleri kazanıp kazanmadıklarını belirlemede öne çıkmaktadır. Öğretmenler, öğrencilere bu becerileri kazanmaları için fırsatlar sağlamada ve ilerlemelerini değerlendirmede önemli bir rol oynamaktadır. Hedeflenen eğitim standartlarına ulaşmanın ilk adımı öğretmen adaylarının eğitimidir. Bu nedenle, öğretmen adaylarına bağlam temelli metinler oluşturma ve bağlama uygun sorular formüle etme yeteneği kazandırmak büyük önem taşımaktadır. Bu varsayımdan yola çıkarak, bu çalışma fen bilgisi öğretmen adaylarının bağlam temelli soru yazma becerilerini kapsamlı bir şekilde incelemeyi amaçlamaktadır.* ***Yöntem:*** *Çalışma, nitel araştırma yöntemlerinden biri olan vaka çalışması tasarımı kullanılarak yürütülmüştür. Katılımcılar 34 fen bilgisi öğretmen adayından oluşmuştur. Çalışma, araştırmacı tarafından yürütülen "Eleştirel ve Analitik Düşünme" dersinde gerçekleştirilmiştir. Bu dersi alan fen bilgisi öğretmen adayları, seçtikleri konularda bağlam temelli metinler oluşturmuş ve metinlerinden yola çıkarak her PISA bilimsel okuryazarlık düzeyi için yedişer soru hazırlamışlardır. Bağlam temelli metinlerin içerikleri ve öğretmen adaylarının hazırladıkları sorular araştırmanın verilerini oluşturmaktadır. Araştırma verileri, nitel veri analiz yöntemlerinden biri olan betimsel analiz kullanılarak analiz edilmiştir. Veri analizi sürecinde farklı araştırmacılar tarafından analizler yapılmış ve tutarlılık sağlanmıştır.* ***Bulgular:*** *Bulgular, fen bilgisi öğretmen adaylarının hazırladıkları bağlam temelli soruların hedeflenen PISA bilimsel okuryazarlık düzeyleriyle orta düzeyde uyumlu olduğunu ortaya koymuştur.* ***Sonuç:*** *Araştırma sonucunda, fen bilgisi öğretmen adaylarının bağlam temelli soru yazma becerilerinin lisans eğitimleri sırasında verilecek eğitimlerle ve konu alanı uzmanlarının gözetiminde yapılacak soru yazma etkinlikleriyle daha da geliştirilebileceği önerilmiştir.*

Introduction

The attempt to restructure education systems will be inevitable in the 21st century, brought about by social changes due to technological developments. In the 21st century, the developments experienced as a result of the revision of education and training activities are also changing the role of students, putting them in a position where they can criticise, question, use knowledge in everyday life and solve problems. This is possible by aiming to provide students with high-level thinking skills and to develop these skills. At this point, in addition to the transfer of knowledge in the learning process, the effectiveness of assessment and evaluation systems in the process of providing students with high-level thinking skills brings the seriousness of assessment and evaluation systems to the fore. Assessment and evaluation systems play a crucial role in managing students' individual learning processes.

In a teaching based on 21st-century skills, it is important to create measurement and evaluation tools in this respect. At this point, science teachers are expected to have a skill-oriented measurement and evaluation understanding and the necessary skills in order to create measurement and evaluation in science classrooms (Arık Güngör & Saraçoğlu, 2023; Bolat et al., 2022). In the field of science, the concept that covers the skills specific to this field is science literacy. Science literacy is expressed as a competence that

requires individuals to think rationally while producing solutions to the problems they face. Science teaching endeavours to enable individuals to become science literate, reflecting the skills and qualities they should have (Yetişir et al., 2018). Science literacy is among the main goals of science education (Forbes et al., 2020; Oliver et al., 2021).

It is important to make use of measurement and evaluation practices that can make significant contributions in raising scientifically literate individuals by associating them with daily life (Doğru & Çepni, 2023). Various approaches have been developed to present science learning in a clearer and more interesting form (Podschuweit & Bernholt, 2018), and these goals in the process of developing individuals' science literacy overlap with the goals of the context-based learning approach (Bülbül & Aktaş, 2013). The context-based approach has recently been highly preferred and increasingly adopted in science education. It is accepted as a starting point for learning scientific concepts (Bennett et al., 2007; Deveci & Karteri, 2022; Pilot & Bulte, 2006; Tariq & Saeed, 2021).

The context-based approach, which is promising in science teaching, is a teaching style based on the constructivist approach in which students use the science concepts they learn in the lesson by associating them with daily life (Ayvacı & Yamaçlı, 2023; King & Henderson, 2018; Sak, 2018; Tariq & Saeed, 2021). It can provide students with many learning opportunities at the point of structuring scientific knowledge and plays an important role in the development of scientific literacy skills (Hadiprayitno et al., 2024; Holbrook, 2008; Tolppanen et al., 2019). By supporting the development of students' inquiry skills (Overman et al., 2014; Trimmer et al., 2009), it aims to improve the quality of science teaching (King & Ritchie, 2013). Context-based approach positively affects student achievement compared to traditional teaching approaches (Kara & Dönel Akgül, 2023; Mete & Yıldırım, 2016; Tsadik Getu et al., 2024). In addition to the fact that context-based learning has become a common approach used in the science education process, it is stated that it has some disadvantages. Gilbert et al. (2011) stated that the main difficulties of context-based learning in terms of science are: goal obsolescence, overloading content, inconsistent learning, and inability to transfer learning to new contexts effectively. Another factor that makes context-based learning difficult is that the process of creating context is difficult and takes a long time (Mete & Yıldırım, 2016). Walan et al. (2016) identified several challenges, including finding an appropriate context, time constraints, individual differences among students, crowded classrooms, and difficulties in using materials. Similarly, another study also stated that it may be limited in terms of making time and space elements appropriate (Sak, 2018; Srinivasa et al., 2022).

The worldwide science curriculum framework shows a tendency towards context-based learning and the judgement that this tendency structures the curriculum is at the forefront (Vos et al., 2011). The success of context-based learning is critically related to the quality of curriculum materials and their implementation in the classroom. These materials include assessment tools, which are a fundamental component of teaching (Bortnik et al., 2021; De Putter-Smits et al., 2022; Elmas & Eryılmaz, 2015). The development of a qualified assessment and evaluation tool can be considered as an

important criterion in meeting the objectives of context-based learning. At this point, the need for context-based questions emerges. The context-based approach can be used not only in the teaching part of the lesson but also in the evaluation part with effective questions (Ceylan, 2024). It will be inevitable to integrate context-based questions into measurement and evaluation systems in parallel with the importance of science literacy (Çepni et al., 2020). Context-based questions can be explained as scripting science concepts by adapting them to real life (Ahmed & Pollitt, 2007). It can also be defined by Elmas & Eryılmaz (2015) as questions in which science topics and concepts are written by making a connection with a context. However, it is stated that context-based questions are not based on memorisation and individuals cannot reach a solution without being involved in the thinking process. Context-based questions aim to combine theoretical knowledge and practice and to arouse interest and curiosity by associating the scientific concepts taught in the lessons with daily life phenomena (Bellocchi et al., 2016; Fensham & Rennie, 2013). Context-based questions can play a key role in achieving the set goal (Ayvacı & Yamaçlı, 2023) and increase success in current exams (Sak & Kaltakçı Gürel, 2019). Kurbanoğlu & Nefes (2015) emphasise that such questions are promising and have the potential to reduce test anxiety and improve scientific attitudes in students.

It is pointed out that the question quality of context-based questions should be constructed based on some basic criteria (Ayvacı & Yamaçlı, 2023; Elmas & Eryılmaz, 2015):

- It should include an objective and implicit problem of daily life.

- Science concepts, principles, formulae and laws should be in a pattern with the context of the question. The question should be directed to the appropriate target audience.

- The answer to the question is based on realistic data and not rote memorisation.

On the other hand, the process of preparing context-based questions is of critical importance. It is expected that the validity of the selected contextual question should not be jeopardised (Ahmed & Pollitt, 2007; Bellocchi et al., 2011). Care should be taken to ensure that the pattern between the context and science concepts is very strong. Context and constructed science concepts should be avoided as two separate structures. In addition, unnecessary details of the questions should be avoided (Elmas & Eryılmaz, 2015).

It can be said that TIMSS and PISA questions stand out in terms of meeting the aim of context-based questions to transform science subjects into real-life situations and to produce effective solutions to daily life scenarios (İlhan & Hoşgören, 2017; Nasırlıel & Ünal, 2021). PISA exams, which evaluate students‘ skills in different fields and have context-based questions, measure students’ skills of associating with daily life as well as their knowledge in learning areas (Bayburtlu, 2021; Sak & Kaltakçı Gürel, 2019; Şan & İlhan, 2022). PISA questions can act as a catalyst by providing effective opportunities for students to gain the desired goals and skills in context-based learning. PISA is an assessment for the use of students' high-level skills and is an international exam based on a context-based measurement approach (Doğru & Çepni, 2023). It is considered as a study

that questions international education systems by evaluating the skills and competences of 15-year-old students in the three basic areas of reading, mathematics and science (Teig et al., 2022). In 2022, a total of 81 countries, including 37 OECD members, participated in PISA, which started with the participation of 32 countries (MoNE, 2022).

It is accepted as an important argument in the process of shaping the education agenda and reflecting the planned education policies into practice (Aydın et al., 2018). PISA questions are in a serious position at the point of raising science literate individuals, which is one of the goals of science education, and ensuring the personal development of individuals (Çepni, 2016). PISA applications show positive results in terms of strengthening students' science literacy with the guidance provided to countries (Teig et al., 2022; Oliver et al., 2021).

PISA success has proved the necessity for students to have a solution-oriented approach to the problem, to make inferences and to be science literate individuals (Kömürcü & Yenilmez Türkoğlu, 2022). Success in PISA exams require students to set cognitive skills such as making inferences and interpretations, exhibiting a critical attitude and establishing a relationship with daily life in direct proportion to the rising level (Benzer, 2019).

PISA assessment tools targeting science literacy consist of a series of cognitive and affective questions based on a real-life context (Fensham, 2009). At the same time, it is a source of reforms to be made by supporting the decisions made on education to be put into action (Alatlı & Bökeoğlu, 2018). The results of the PISA exam play a guiding role in shaping national education policies, curricula, textbooks and teacher competencies (Benzer, 2021). PISA, which is an international student monitoring application developed through the Organisation for Economic Cooperation and Development (OECD), is an exam defined as the Programme for International Student Assessment (Çiçek & Dilekçi, 2022). PISA, which was administered for the first time in the world in 2000, covers the assessment of knowledge and skills in reading, mathematics and science literacy (Benzer, 2019). Like many countries, Türkiye, which aims to see its position at the international level, has also attempted to shape its curricula by structuring its education policies based on PISA (Benzer, 2021).

It is emphasised that science literacy is an area that is aimed to be tested in PISA studies, and the importance given to the application of science course knowledge in line with the facts that exist in real life is pointed out (MoNE, 2024). In the PISA study, Türkiye analyses the concept of science literacy in three dimensions: competencies, types of scientific knowledge and general content areas. Competences are explained as being able to explain the effects of natural realities on technological products and society, scientific knowledge types as being able to search for answers to questions using scientific inquiry methods with existing knowledge, and general content areas as interpreting the findings scientifically and evaluating the results. On the basis of student scores, competence levels were defined to show what students can do (MoNE, 2022). The assessment was first conducted internationally in 2000 and Türkiye in 2003, and the number of countries and students participating in the exam, which is applied every three years, has gradually

increased. Based on science literacy, 7 PISA science literacy proficiency levels, namely 1b, 1a, 2, 3, 4, 5 and 6, were included from the lowest to the highest level of PISA (MoNE, 2022). According to PISA, among the 6 levels of science literacy in which different competences are defined, levels 1b and 1a are considered as low-level performance, levels 2, 3 and 4 as minimum performance, and levels 5 and 6 as high-level performance (MoNE, 2016). Although PISA results show variability on a yearly basis, the rise in 2012 and the decline in 2015 draw attention. However, after the 2018 PISA, Türkiye showed a significant improvement compared to other countries (Benzer, 2021; MoNE, 2019). In the 2022 PISA, Türkiys ranked 34th in science among 81 participating countries and 29th among 37 OECD countries (MoNE, 2022). In PISA 2022, Türkiye ranked above the average of the countries in mathematics, science and reading, achieving an average score of 476 in science, surpassing the country average (OECD, 2023).

It is possible to find literature studies on writing context-based questions in science education and PISA questions. When the relevant literature was reviewed, this study aimed to conduct an in-depth examination of science teachers' context-based question-writing skills. Teachers were given context-based question writing training and asked to write context-based open-ended questions. The study showed that teachers learned context-based question structures that measure scientific literacy (Çepni et al., 2020). In another study, the use of context-based questions written by science teachers participating in the training in written exams was examined (Ülger et al., 2022). Al-Rosaa (2023) tried to determine the extent of context types and contextual question areas in intermediate-level science textbooks. In another similar study, it was aimed to examine the questions in 5th-8th grade science textbooks according to PISA science literacy proficiency levels (Kömürcü & Yenilmez-Türkoğlu, 2022). Selçuk & Tezbaşaran (2022) examined the distribution of some eighth-grade science test items in different national-level exams according to PISA science literacy competency levels. Similarly, Tuna and Kapucu (2022) examined the LGS science questions of the last four years in terms of PISA science literacy dimensions. In the study conducted by Ar (2019), science teachers were given context-based question preparation training, teachers were enabled to prepare open-ended questions and their thoughts about this process were revealed. After the literature review, the aim of the current study was shaped by the lack of studies in which science teachers engaged in context-based question writing and the resulting questions were evaluated according to PISA science literacy levels. In addition, the study aims to contribute to the field of science education and provide implications for researchers.

Writing questions by associating them with real life and without interfering with the meaning of concepts involves a serious process (Ahmed & Pollitt, 2007). The need for teachers who have the skills to prepare context-based questions and have the competence to transfer knowledge to daily life and transform it into a form suitable for students is noteworthy (Ülger et al., 2022). It has been stated in different studies that teachers do not prefer to go beyond traditional measurement tools and do not have the necessary experience (Çoruhlu et al., 2008; Ülger et al., 2022; Yıldırım, 2020). Teachers' creating their own questions is promising for science teaching, but a holistic perspective on the practice is missing (Herranen & Aksela, 2019). It would not be wrong to say that this

situation points to the need to include teachers in the context-based question writing process. The contributions of the current study are obvious in revealing the strengths and weaknesses in context-based question writing processes by integrating teachers into context-based question writing activities. The results of this study may create different perspectives in terms of providing teachers with a qualified context-based question writing standard, developing context-based text creation and question writing skills. It will provide a great opportunity by contributing to the creation of questions that encourage critical thinking, scientific thinking and problem-solving skills in line with the course content. Therefore, determining the qualities of context-based questions prepared by teachers can provide insight into their question-writing pedagogies. On the other hand, it is expected to be a source of ideas by guiding the studies that will focus on the context-based question writing and the evaluation of the questions written by teachers. It is recommended to transfer information about PISA or its contents to pre-service teachers and integrate them into the field courses (Benzer, 2021). In this direction, the purpose of the study was shaped at the point of moving the context-based question writing skills of pre-service science teachers to a more qualified position. In this study, it is aimed to examine the context-based question writing skills of pre-service science teachers in an in-depth manner.

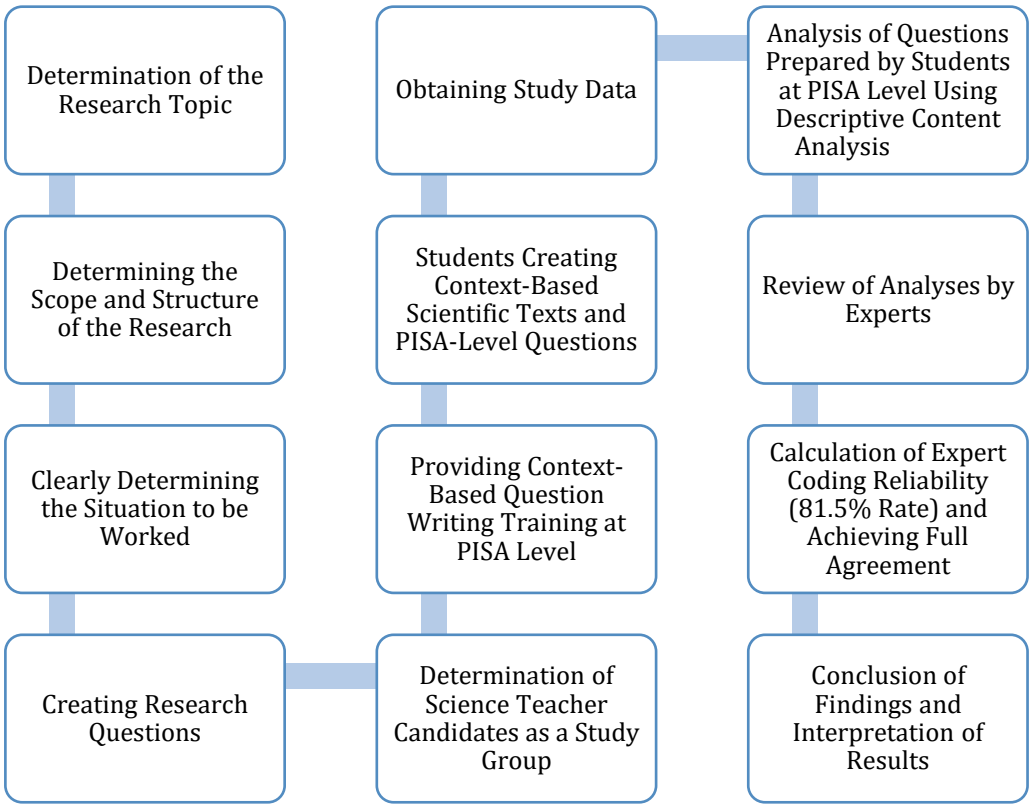
Methodology

Research Design and Process

The study was conducted with a case study design, one of the qualitative research methods, in accordance with its purpose. The study was shaped by a descriptive case study approach aiming to examine the context-based question writing skills of pre-service science teachers in depth.

The case study investigates the situation in real life, current context and environment. It is an in-depth description and examination of a limited system. An individual, group and environment can be an example of the situation to be studied (Creswell, 2018; Merriam, 2018; Yıldırım & Şimşek, 2018). In other words, it is explained as examining, investigating and defining a phenomenon with its reality (Yin, 2013). Yıldırım & Şimşek (2018) highlighted the steps that can be followed in the form of forming research questions and developing sub-problems, determining the unit of analysis, determining the situation to be studied, selecting individuals, collecting, analysing and interpreting data while conducting a case study. Based on the studies in the literature on research steps (Çepni et al., 2020; Herranen et al., 2019; Ülger et al., 2022), the case study steps followed in the current study are given in general terms (Figure 1).

Figure 1: *Case Study Steps Followed for the Conducted Study*



When Figure 1 is analysed, the scope of the study was determined and the situation to be examined was revealed. Within the framework of the research questions determined in this direction, pre-service science teachers were determined as the study group. As a result of the context-based question writing seminar training given to pre-service science teachers, they were asked to create context-based scientific texts and write questions at the PSI level. The questions prepared at the PSI level, which constitute the data set of the study, were analysed by descriptive content analysis. The 7 questions belonging to each of the PISA science literacy levels that the pre-service teachers wrote in accordance with the text were evaluated by taking into consideration the context-based texts they created in free subjects. In the last stage, the findings obtained were finalised and the results were interpreted. In addition, suggestions were made based on the interpretations of these results.

Working Group

The study group was determined by using the convenience sampling method, one of the purposeful sampling types. The sampling type used aims to select a sample group that can accelerate the research and that the researcher can easily reach (Bhardwaj, 2019; Fraenkel & Wallen, 2012; Yıldırım & Şimşek, 2018).

The students studying in the department of science teaching at the faculty of education consisted of 33 female and 1 male pre-service teachers. It was taken into consideration that the pre-service teachers were included in the study on a voluntary

basis, in line with their own wishes. The country where the research was conducted has an average science literacy score in the most recent 2022 PISA exam and the participating pre-service teachers have not received any training on PISA before.

Implementation Process and Obtaining Data

The data of the study were obtained within the framework of the seminar course on scientific text writing, PISA exam, science literacy in PISA and the creation of PISA-level questions based on the text context. In the seminar courses, it was aimed to inform the pre-service teachers and to ensure that the skills they had acquired in previous courses, such as writing questions, writing stories with scientific content, and resource synthesis, which would form the basis for them until then, were used in the focus of PISA text and questions. The seminar course of the research lasted for two weeks and 4 hours in total. Within the scope of the seminar, firstly, the nature of PISA exams was introduced. Its purpose, how often it is conducted, its relationship with science education, the definition and levels of science literacy, the skills included in the levels, and the evaluation method were stated. Afterwards, the preparation of a scientific context-based text, accessing and synthesising the sources, creating questions based on the text and meeting the PISA science literacy levels of these questions were explained and the seminar course was completed in an interactive environment with the students.

The pre-service science teachers who took the course created context-based scientific texts on the free topic they chose. Based on the texts they created for each of the PISA science literacy levels, they prepared questions at 7 levels of field skills and conceptual skills associated with PISA science literacy proficiency levels. Therefore, 7 questions prepared by each pre-service science teacher for each of the 7 proficiency levels of PISA science literacy constitute the data set. The distribution of the learning areas of the science curriculum to which each context-based scientific text prepared by pre-service science teachers belongs to is given (Figure 2).

Figure 2: *Science Curriculum Learning Areas Distribution of Context-Based Scientific Texts*

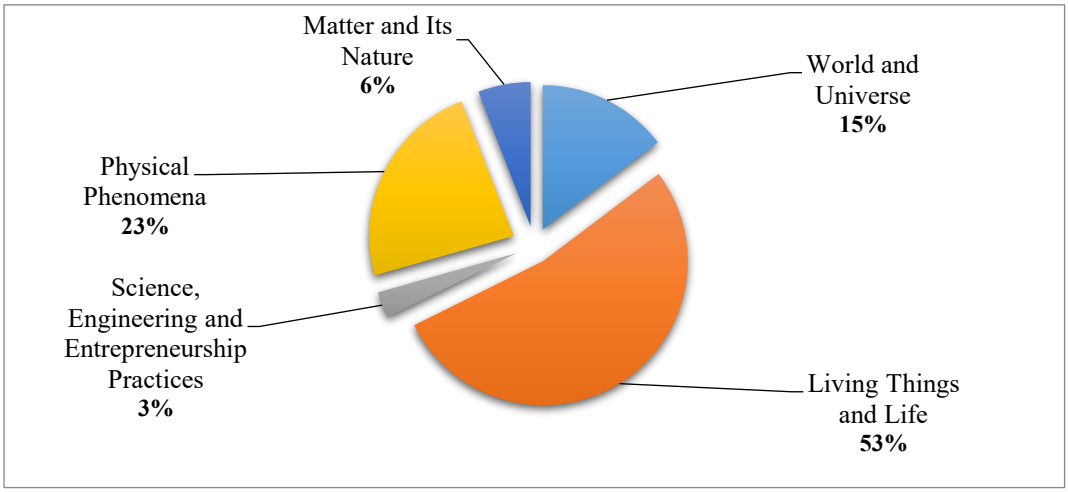


Figure 2 shows the distribution of the learning areas of the science curriculum to which each context-based scientific text prepared by pre-service science teachers belongs. Figure 2 shows that 53% of the pre-service science teachers wrote free context-based scientific texts in the learning areas of 'Living Things and Life', 23% in 'Physical Phenomena', 15% in 'World and Universe', 6% in 'Matter and Its Nature' and 3% in 'Science, Engineering and Entrepreneurship Practices'. It is understood that students created texts mostly in the learning areas of 'Living Things and Life' and 'Physical Phenomena'.

In addition, the subject distributions of the contents of each context-based scientific text prepared by pre-service science teachers in the 2018 national science curriculum learning areas distributions are given (Table 1).

Table 1: *Topic Distributions of Context-Based Scientific Texts for Science Curriculum Learning Areas*

Learning Area	Question Written Subject Area	Question Written Text Subject	Student Code
World and Universe	Seasons and Climate	Climate and Weather Movements	**S2**
	Solar System	Misty Atmosphere	**S5**
	Solar System	Saturn	**S9**
	Solar System	Galaxy	**S21**
Living Things and Life	Biotechnology	Live Cloning	**S3**
	Cell Division	Cancer	**S4**
	Ecosystem	Ecosystem Balance	**S6**
	Global Environmental Problems	Drought	**S12**
	Biodiversity	Unconscious Hunting	**S13**
	Reproduction and Growth in Humans	Pregnancy	**S14**
	Destructive Natural Events	Earthquake and Ways of Protection	**S15**
	DNA and the Genetic Code	Adaptation and Modification	**S16**
	Circulatory System	How Our Heart Works	**S17**
	Global Environmental Problems	Global Warming	**S19**
	Our Body and Health	Diabetes Disease	**S20**
	Genetically Modified Foods	Frozen and Packaged Foods	**S22**

	DNA and the Genetic Code	Model Organism	**S23**
	Biodiversity	Butterflies of Tükiye	**S24**
	Global Environmental Problems	Climate Change	**S25**
	Living Things and the Food Chain	Food Chain and Flow	**S26**
	Biodiversity	Convention on Biological Diversity	**S28**
	Environmental Pollution (Acid Rain)	Acid Rain and Human Health	**S29**
	Environmental Pollution	Water (Sea) Pollution	**S30**
Physical Phenomena	Force and Energy	Work and Energy	**S7**
	Waves	Doppler Effect	**S8**
	Friction Force	Vehicles and Air Friction	**S10**
	Fraction Force	Aircraft Motion and Air Friction	**S1**
	Waves	Water Wave	**S18**
	Interaction of Ligh twith Matter	Absorption of Light	**S31**
	Electricity Transmission	Piezo Electric	**S32**
	Electricity Transmission	Conductor-insulator	**S33**
Matter and its Nature	Renewable Energy Sources (Solar)	Solar Panels	**S27**
	Nature Cycles	Water Cycle	**S34**
Science, Engineering and Entrepreneurship Applications	Engineering	Artificial Intelligence	**S11**

When Table 1 is examined, the distribution of the topics of context-based scientific texts for the learning areas of the science curriculum is seen. The subject area and the topic of the scientific text written by each pre-service science teacher participating in the study can be accessed from Table 1. It is understood that pre-service science teachers wrote texts on the solar system in the learning area of "Earth and the Universe", texts on the human body and environmental problems in the learning area of "Living Things and Life", texts on force, electricity and light in the learning area of "Physical Phenomena", and texts on energy sources and matter cycles in the learning area of "Matter and Nature". After the seminar course, the pre-service science teachers prepared 7 questions each from 7 competency levels of PISA science literacy based on scientific texts in free subjects in a 2-week period. The researcher did not intervene in the text and question preparation processes of the preservice science teachers. The researcher carried out the implementation process effectively and the data were collected.

Data Analysis

The scientific texts prepared by pre-service science teachers and the context-based questions they created based on the texts in accordance with the PISA science literacy proficiency levels constitute the data set of the study. The research data were analyzed by applying descriptive analysis from qualitative data analysis methods. The questions prepared by the pre-service teachers were analyzed deductively and each question was based on the question level to which it was related. The process of placing the questions appropriately at the question level was carried out gradually and in cooperation with experts (Eylem et al., 2021). After the completion of the analysis process, the findings were finalized. Descriptive content analysis, which is accepted as a deductive analysis, is

a process that includes (i) creating a framework for analysis, (ii) coding the data, (iii) defining the findings, and (iv) interpreting the findings (Yıldırım & Şimşek, 2018; Creswell, 2018).

In the first stage, the scientific texts written by all pre-service science teachers and the context-based questions they wrote based on these texts were analyzed. During the review process carried out by the expert researchers, the papers of the pre-service teachers were checked, their preparation of the questions was reviewed and no data paper that could be excluded from the analysis was found. Each paper that constituted the data set of the pre-service teachers was numbered and made ready for analysis. Each paper belonging to 34 students was numbered and coded as S1, S2, ...S34 and "S" stands for student. Each scientific text written by the students was examined and included in the subject area of the science curriculum to which it belonged. In the next stage, each text and the questions related to the text were analyzed in depth, and the questions that were primarily prepared were separated into questions that could be answered from scientific texts and questions that could be answered directly. Questions whose answers could be directly inferred from the text were determined as the lowest level. Questions that could be directly inferred from the text were handled at level 1a because they were questions that students could easily reach the answer. Even if the questions written by the students were aimed at explaining complex situations, hypothesizing or analyzing, questions that could be answered directly from the text were not considered as high-level questions. Even if the questions prepared by the students were written at levels 5 and 6, and even if they seemed to be high-level questions, the questions that were directly extracted from the text were handled at level 1b. After the parsing process carried out in depth by the expert researchers, the level-appropriate question writing situations of the pre-service teachers were evaluated as questions that could be answered from the context-based texts they created and questions that could be answered directly. The answerability of questions based on context-based scientific texts was determined (Figure 3).

Figure 3: *Answerability of Questions Based on Context-Based Texts*

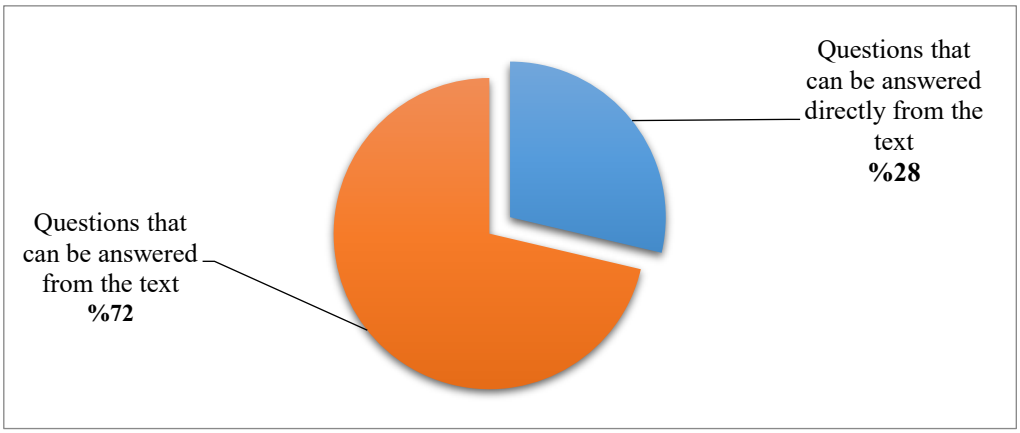


Figure 3 shows the answerability of the questions based on context-based texts created by preservice science teachers. It is understood that pre-service science teachers posed a total of 222 questions. It was determined that 35 (28%) of the questions prepared

by pre-service science teachers were questions that could be answered directly from the context-based texts they created, while 88 (72%) were questions that could be answered as a result of inferences made from the texts. It was determined that the questions prepared by the majority of the pre-service teachers consisted of questions that could be answered from the context-based texts they created.

In the next step, the level appropriateness of the prepared questions, then the level distribution of the appropriate questions, and finally the correct and incorrect levels of the questions prepared for each level were examined in detail. The questions and texts prepared by 3 researchers who are experts in the field of science education were evaluated based on the criteria of the levels of the questions, the behaviors of the students whose explanations were at the science literacy level, the associated domain skills and conceptual skills. Each question level was analyzed by taking into account the qualities that students should have according to PISA science literacy proficiency levels (PISA, 2022) (Figure 3).

Figure 4: *PISA Science Literacy Proficiency Levels and Student Behaviors at Proficiency Levels*

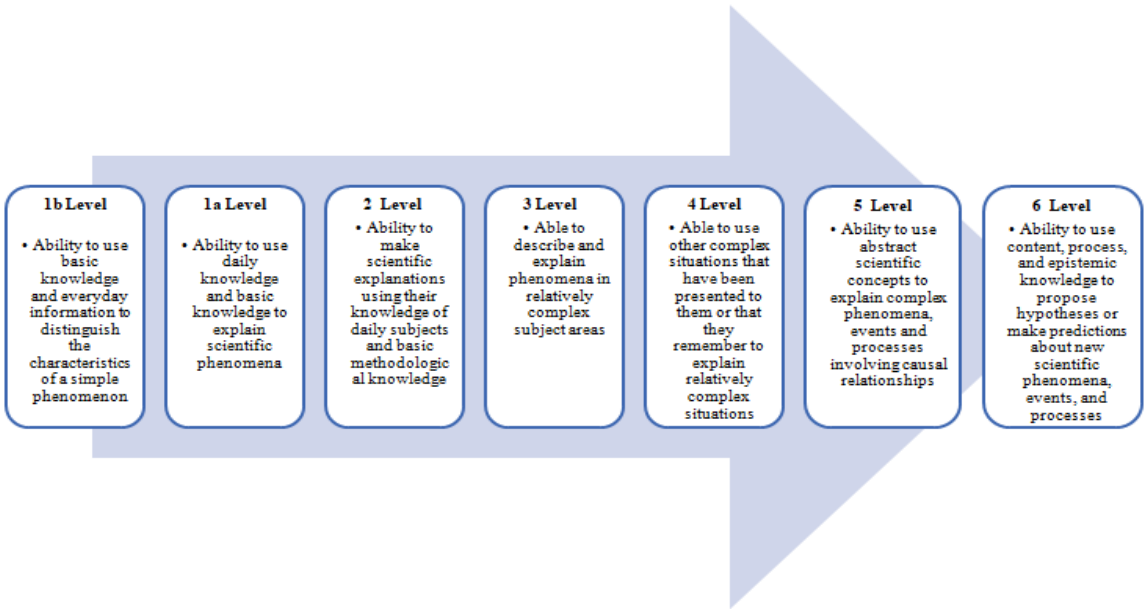


Figure 4 shows PISA science literacy proficiency levels and student behaviors at proficiency levels. It is understood that there are seven proficiency levels within the scope of science literacy proficiency. Following the content of Figure 4, each question level written by the students in the context of the criteria determined was analyzed according to whether or not it met the criteria of the existing question level. Questions that met the criteria for their designated level were classified; accordingly, otherwise, they were categorized into the most appropriate level based on their function and content. The data of each pre-service teacher was analyzed and the question levels they wrote were placed in the question levels that met the appropriate criteria. The question levels written by the students were checked by three expert researchers to see whether they met the question levels. After the analyses carried out by each expert researcher, the question level was placed in the most appropriate level with the consensus of the three experts. An example

of placing the questions analyzed in the data analysis process at the appropriate question level is given. The question levels written by the pre-service teacher coded S11 and the question levels placed by the researchers are presented (Table 2).

Table 2: *An Example of Placing the Questions Analyzed in the Data Analysis Process to the Appropriate Question*

	No	*Student*	*Expert 1*	*Expert 2*	*Expert 3*	*Question Level Rationale for Inclusion*
Coded S11 Science Teacher Candidate	Q1	Level 1b	Level 2	Level 2	Level 2	This question is not at level 1b because it is not very simple to use the information from the graph and does not allow the student to interpret it. The question is at level 2 because students are expected to make inferences by analyzing the set of graphs and interpret them within this framework.
	Q2	Level 1a	Level 2	Level 2	Level 2	This question is not at level 1a because it is designed to stimulate students' decision-making mechanisms. The question is at level 2 because it is based on students reaching a conclusion by adding their own interpretation within the framework of the information given to them.
	Q3	Level 2	Level 1b	Level 1b	Level 1b	This question is not at level 2 because it aims to lead students to conclusions without making comparisons or examining any design. The question is at level 1b because it directs students to explain their knowledge of daily topics and basic knowledge without providing information in a simple way.
	Q4	Level 3	Level 3	Level 3	Level 3	This question is at level 3 because it tests the ability to distinguish between knowledge and epistemic and methodological knowledge, with the support provided in subject areas that can be considered a bit more complex.
	Q5	Level 4	Level 4	Level 4	Level 4	This question is at level 4 because it offers the opportunity to use the information presented and one's own knowledge to explain situations that are considered complex, such as the downsides of AI.
	Q6	Level 5	Level 5	Level 5	Level 5	This question is at level 5 because students use it to distinguish and explain the advantages and disadvantages of AI by demonstrating causal relationships, keeping decision-making skills active.
	Q7	Level 6	Level 5	Level 5	Level 5	This question is not at level 6 because it is not sufficient to encourage students to think at a higher level and it does not test students' higher analysis skills in decision making. The question is at level 5 because they are able to interpret data that they are not familiar with and are able to draw conclusions and justify them using the data.

When Table 2 is examined, the process followed by the expert researchers while assigning the question level written by the student to the question level to which the student belongs is seen. It is understood how the questions written by the pre-service teacher coded S11 were placed at the level deemed appropriate with the consensus of three experts after the level assignment. The level assignments of each pre-service teacher's questions were carried out in depth and in an extremely meticulous manner. After placing each question in the appropriate category, the questions prepared and not

prepared at the appropriate question level were determined. Afterwards, the pre-service science teachers' preparation of questions based on contextualized texts was analyzed in general. The situations of preparing questions appropriate to the targeted level based on context-based texts and not preparing questions appropriate to the level were revealed. In addition, the question level distributions of 123 questions prepared in accordance with the level based on scientific texts were also determined.

In the last analysis stage, each of the seven proficiency levels within the scope of PISA science literacy competency was determined as a theme. The question levels belonging to each theme were discussed. For example, the level distributions of the questions prepared for "Level 1b" of PISA science literacy competency levels were determined. The questions that the pre-service teachers thought belonged to "Level 1b" were analyzed by experts and tables expressing which question level they corresponded to were obtained. In this way, the process of evaluating the questions formed by the pre-service teachers based on context-based texts as preparing questions appropriate to the targeted level and not preparing questions appropriate to the level was continued. Similarly, for each question level (1b,1a,2,3,4,5,6 Levels), 6 rounds of evaluation process were followed. Based on the question levels, the number of each pre-service teacher who wrote a question belonging to their level was determined as a frequency value. Percentages were also calculated in line with the frequency values. After the analysis process, the findings were presented in the form of tables and graphs. In addition, sample question sentences of pre-service teachers belonging to the question levels were also included.

Validity and Reliability of the Study

In order to ensure research validity, each stage followed in the data analysis section was clearly stated. It is very important to compare and confirm the results obtained in the analysis of the data obtained in the study (Miles & Huberman, 2016; Yıldırım & Şimşek, 2018). It is preferred to ensure coder agreement by reaching a common consensus on the data coded by sharing ideas (Richards & Hemphill, 2018). From this point of view, the validity of the study results was increased by making repeated checks by 3 field experts during the analysis phase. After the analysis process carried out by 3 different researchers, it was determined that there were 190 agreements and 43 disagreements. Therefore, the 81.5% agreement rate shows that the study is highly reliable (Miles & Huberman, 2016). However, after the percentage of agreement, the researchers came together again for the inconsistent analyses and discussed the level until the experts reached a full consensus.

Research Ethics Implementation Process

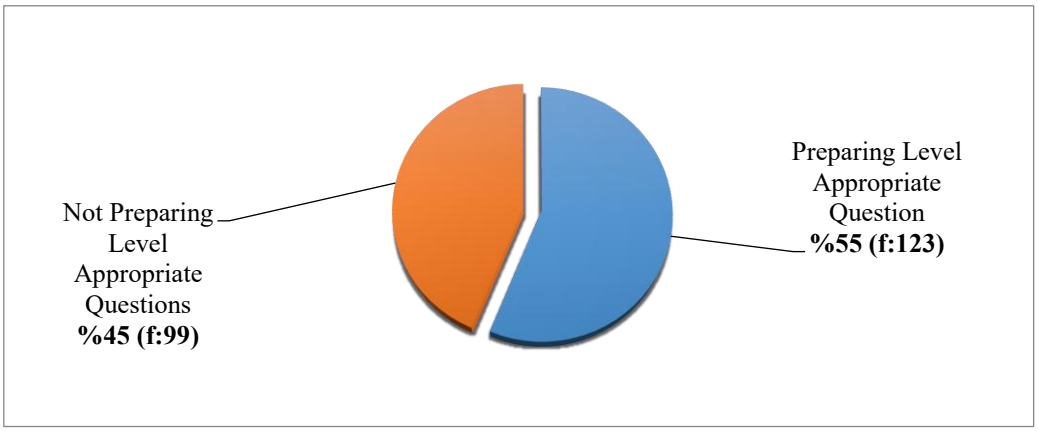
The confidentiality principle was stated that the student responses obtained within the scope of the research would not be used anywhere other than the scientific study and the respondents were assured that their identities would be kept confidential. In addition, the research process was carried out by giving codes to each of the students instead of their

names and surnames. Throughout the research process, efforts were made to avoid possible ethical problems that would negatively affect the study.

Findings

The findings obtained as a result of the analysis of the context-based questions prepared by pre-service science teachers in accordance with the PISA science literacy proficiency levels based on the scientific texts they prepared are presented. While presenting the findings, a flow from general to specific was followed, so first the level appropriateness of the prepared questions, then the level distribution of the appropriate questions, and finally the detailed results obtained regarding the correct and incorrect levels of the questions prepared for each level were exhibited. By evaluating the questions formed by pre-service science teachers based on context-based texts as preparing questions appropriate to the targeted level and not preparing questions appropriate to the level, the findings related to the preparation of the question appropriate to the level are given (Figure 2).

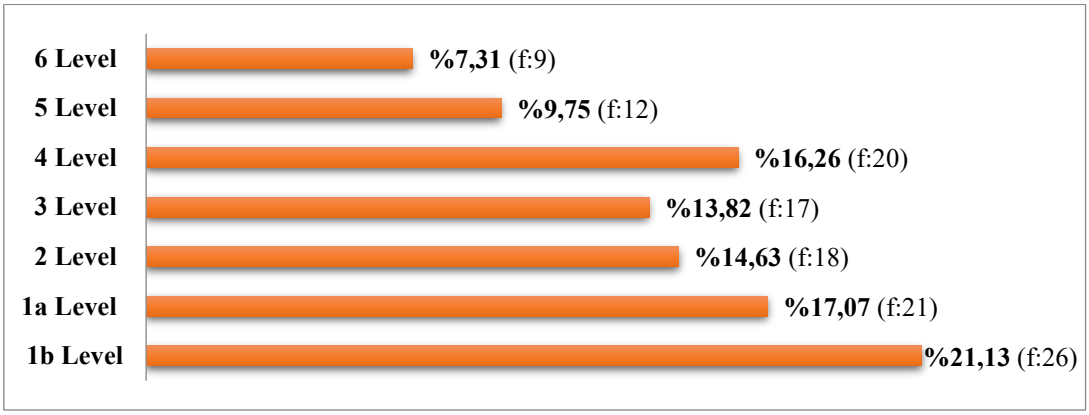
Figure 5: *Preservice Science Teachers' Preparation of Questions Based on Context-Based Texts*



When Figure 5 is examined, it is seen that pre-service science teachers prepared questions appropriate to the intended level based on context-based texts and did not prepare questions appropriate to the intended level. It was determined that 123 (55%) of the pre-service science teachers prepared questions appropriate to the intended level. On the other hand, 99 (45%) of them could not prepare questions appropriate to the intended level.

The question level distributions of the 123 questions prepared in accordance with the level that the pre-service science teachers formed based on context-based texts are given (Figure 3).

Figure 6: *Level Distributions of the Questions Prepared by the Prospective Science Teachers in Accordance with the Level*



When Figure 6 is examined, it is seen that the question level distributions of the questions belonging to the questions prepared in accordance with the level that the pre-service science teachers formed based on context-based texts. It is understood that 26 (21,13%) of the questions belong to level 1b, 21 (17,07%) to level 1a, 18 (14,63%) to level 2, 17 (13,82%) to level 3, 20 (16,26%) to level 4, 12 (9,75%) to level 5 and 9 (7,31%) to level 6. It was determined that pre-service science teachers were able to write questions appropriate to each level. However, it can be seen from Figure 3 that the preservice science teachers wrote questions appropriate to levels 1b and 1a the most and to level 6 the least.

The level distributions of the questions prepared by pre-service science teachers for "Level 1b", one of the PISA science literacy proficiency levels, and examples of questions belonging to the level are given (Table 3).

Table 3: Level Distributions and Question Samples of the Questions Prepared by Pre-Service Science Teachers for "*Level 1b"*

Question Levels	Frequency	Percentage (%)	Student Teacher Question Sample
1b Level	26	76.47	**S12:** *Write the definition of drought according to what is given.*
1a Level	4	11.76	**S7:** *Which and which of the quantities increase as the ball goes up from the bottom?*
2 Level	2	5.88	**S5:** *What is the argument in favor of Pluto being so cold?*
3 Level	0	-	-
4 Level	2	5.88	**S20:** *In which of the following cases can it be said that there is a "DiabetesMellitus" disease? (No glucose in urine)*
5 Level	0	-	-
6 Level	0	-	-

When Table 3 is examined, the distribution of the question levels prepared by pre-service science teachers for level 1b is seen. It is understood that 26 of the pre-service teachers (76,74%) wrote questions in an appropriate way for level 1b. In the preparation of questions at level 1b, it was determined that 4 of the pre-service teachers (11,76%) tended to write questions at level 1a, followed by 2 pre-service teachers (5,88%) at level 2 and 2 pre-service teachers at level 4.

In this direction, when the sample question sentences are examined, in the level 1b question prepared ***by the pre-service teacher coded S12***; students are expected to define the term *drought* by including their daily knowledge from a text from a given basic level of knowledge. The question is designed in a way that the answer can be easily reached from the text. Therefore, it was deemed appropriate to be included in level 1b. At this point, it is understood that ***the pre-service teacher coded S12*** was able to formulate questions at level 1b. The question written ***by the pre-service teacher coded S7*** was not only aimed at identifying and expressing a simple experimental setup. In addition to addressing the cognitive level, it emphasizes the connection between two variables. It is based on the comprehension of the variables that change with the movement of the ball. For this reason, it is not at level 1b but at level 1ad. For example, in the question written ***by the pre-service teacher coded S5***, Pluto focused on the view that causes the planet to be cold. While answering the question, the student is expected to use the skill of interpreting data based on the explanations in the text and making a logical inference from the data set. Therefore, it was deemed appropriate to include the question prepared by the ***pre-service coded*** Ö5 in level 2 instead of level 1b***.*** In the question prepared by ***the pre-service teacher coded S20***, it can be stated that the question was evaluated at level 4, not at level 1b, on the grounds that it requires students to make a decision after the analysis filter and to reach the answer with higher level interpretations.
The level distributions of the questions prepared by pre-service science teachers for "Level 1a", one of the PISA science literacy proficiency levels, and examples of questions belonging to the level are given (Table 4).

Table 4*: Level Distributions and Sample Questions Prepared by the Prospective Science Teachers for "Level 1a"*

Question Levels	Frequency	Percentage (%)	Student Teacher Question Sample
1b Level	9	26.47	**S21***: What keeps the stars together in the galaxy?*
1a Level	21	61.76	**S33**: *Can gases become conductive? Explain with an example.*
2 Level	3	8.82	**S11:** *Has artificial intelligence led to changes in different aspects compared to 100 years ago?*
3 Level	1	2.94	**S25***: Is Türkiye's climate changing? Explain.*
4 Level	0	-	-
5 Level	0	-	-
6 Level	0	-	-

When Table 4 is examined, the distribution of the question levels prepared by pre-service science teachers for level 1a is seen. It is understood that 21 of the pre-service science teachers (61.76%) wrote questions appropriately for level 1a. It was determined that 9 of the pre-service teachers (26,47%) tended to write questions at level 1b in the process of writing questions at level 1a. Following this, it was determined that 3 prospective teachers (8,82%) included questions at level 2 and 1 prospective teacher (2,94%) included questions at level 3.

In this context, when the sample question sentences are examined, level 1a question prepared ***by the pre-service teacher coded S33***; students are expected to explain a scientific phenomenon at a basic level without many variables. Students were asked to determine the conductivity of gases and make the necessary interpretation at the point of making them conductive. At this point, it is understood that ***the pre-service teacher coded S33*** was able to formulate a question at level 1a. On the other hand, it can be stated that the ***pre-service teacher coded S21*** was included in level 1b on the grounds that he realized the force of gravity and could answer directly within the framework of his daily knowledge. However, the question prepared ***by the pre-service teacher coded S11*** is designed to mobilize students' decision-making mechanisms. It is based on reaching a conclusion by adding their own interpretation within the framework of the pill information given to the students. Therefore, the question was evaluated at level 2. It can be understood that the question prepared by ***pre-service teacher S20*** was included in the 3 question level instead of the 1a level on the grounds that the students can interpret the data and make sense of a lived phenomenon that may seem partially complex.

The level distributions of the questions prepared by pre-service science teachers for "*Level 2*", one of the PISA science literacy proficiency levels, and examples of questions belonging to the level are given (Table 5).

Table 5: *Level Distributions and Sample Questions Prepared by the Prospective Science Teachers for "Level 2"*

Question Levels	Frequency	Percentage (%)	Student Teacher Question Sample
1b Level	6	18.75	**S14:** *What is effective in determining the sex of the baby?*
1a Level	4	12.5	**S16:** *Which of the following is not an example of modification?*
2 Level	18	56.25	**S5:** *Why don't the hydrocarbon droplets that cause the hazy appearance on the planet Pluto cause such an effect on Earth?*
3 Level	3	9.37	**S28:** *Biological resources are important for biodiversity. What are the biological resources of the country?*
4 Level	1	3.12	**S7:** *Which of the given information about our national weightlifter Naim Süleymanoğlu lifting the barbell is wrong?*
5 Level	0	-	-
6 Level	0	-	-

Note. 2 pre-service teachers did not write questions at level 2.

When Table 5 is examined, the distribution of the question levels prepared by pre-service science teachers for level 2 is seen. It is understood that 18 of the pre-service teachers (56,25%) wrote questions appropriately for level 2. In the preparation of questions at level 2, it was determined that 6of the pre-service teachers (18,75%) tended to write questions at level 1b. Following this, it was revealed that 3 pre-service teachers (9,37%) wrote questions at level 3 and 1 pre-service teacher (3,12%) wrote questions at level 4.

In this framework, when the sample question sentences are examined, in the level 2 question prepared ***by the pre-service teacher coded S5***; He listed the theories trying to explain the cold hazy air formed in the atmosphere of Pluto. However, a scientific

inference is made that the hydrocarbon particles that cause the current hazy appearance do not affect the earth. Therefore, the study aimed to reveal students' ability to interpret data using their basic knowledge. It was aimed to enable them to use their basic scientific knowledge to draw a valid conclusion from a simple data set. At this point, it is understood that the question prepared ***by the pre-service teacher coded S5*** was included in level 2. On the other hand, when the question prepared ***by the pre-service teacher coded S14*** at level 2 is examined, it is stated in the content of the paragraph about pregnancy that the sex is determined depending on the chromosomes of my father. This situation was not included in level 2 on the grounds that the question did not allow for any examination and scientific inference and was deemed appropriate at level 1b. In the question written ***by the pre-service teacher coded S16*** at level ***2,*** the definitions of modification and mutation were given and exemplification was requested. The student is expected to make sense of the definition and perceive that permanent changes are not an example of modification. Therefore, the question was evaluated at the 1a level although it was written at the 2 level because it required a simple inference and interpretation. In the question written by the ***preservice teacher coded S7*** at the 2 level, it is understood that it should take place at a more advanced level at the 2 level because it includes the stages of making sense of the concept of work, doing work in science, reflecting it in daily life and reflecting it in another situation.

The level distributions of the questions prepared by pre-service science teachers for "*Level 3*", one of the PISA science literacy proficiency levels, and examples of questions belonging to the level are given (Table 6).

Table 6: *Level Distributions and Sample Questions Prepared by the Prospective Science Teachers for "Level 3"*

Question Levels	Frequency	Percentage (%)	Student Teacher Question Sample
1b Level	1	3.33	**S13:** *Define what biodiversity is based on the text.*
1a Level	4	13.33	**S1:** *Based on the text, is it the engine or the wings of the airplane that keeps the plane in the air?*
2 Level	7	23.33	**S19:** *What are the human activities that cause greenhouse gases to enter the atmosphere?*
3 Level	17	56.66	**S29**: *Marble pieces were placed in two containers containing vinegar and water, and the next day the pieces were taken out of the containers and dried. The dried marble pieces were weighed. According to this, how can comments be made about the masses of the marble pieces?*
4 Level	0	-	-
5 Level	1	3.33	**S16:** *Observing that the color of primroses placed in an environment with a temperature of 15-20 degrees is red, while primroses grown in environments with a temperature of 25-30 degrees are white, Ezgi asks hermfriend Buse the reason for this situation. What kind of answer could Buse have given?*
6 Level	0	-	-

Note. 4 pre-service teachers did not write questions at level 3.

When Table 6 is examined, the distribution of the question levels prepared by pre-service science teachers for level 3 is seen. It is understood that 17 of the pre-service teachers (56,66%) wrote questions appropriately for level 3. It was determined that half of the pre-service teachers were able to prepare questions at level 3. In the preparation of 3 level questions, it was determined that 7 of the preservice teachers (23,23%) tended to write 2 level questions. Following this, 1 pre-service teacher (3,33%) wrote questions at level 5, 4 pre-service teachers (13,13%) wrote questions at level 1a and 1 pre-service teacher (3,3%) wrote questions at level 1b.

In this framework, when the sample question sentences are examined, in the level 3 question prepared ***by the pre-service teacher coded S29***, the negative effects of acids on the environment are emphasized and it is expected to make sense of the negative effects of acids on the experimental setup. They are asked to explain with clues and supports by using their method knowledge in a simple experiment with certain boundaries that may seem partially complicated. Therefore, it is ensured that students can explain the situation with the help of the experimental setup and the clues in the contextual text and reveal the findings. At this point, it is understood that the question prepared ***by the pre-service teacher coded S29*** was included in level 3. In his question, ***the pre-service teacher coded S19*** listed the gases that cause environmental pollution and stated in the contextual text that these are human activities. However, he did not specify the current human activities and asked the student to explain them. He expects the student to reveal the human activities that harmful gases emitted into the atmosphere can reveal with the help of his basic knowledge. When the question of ***the pre-service teacher coded S1*** is analyzed, the student can easily explain the structure that keeps the airplane in the air with a simple inference based on the contextual text. For this reason, it was decided to include it at level 1a in terms of question level. When the question ***of the pre-service teacher coded S13*** was examined, students were asked to write the definition of biodiversity based on the contextual text. Students will be able to construct this definition using their prior everyday knowledge and a text provided at a basic level. For this reason, it was not evaluated at level 3 in terms of question level.

The level distributions of the questions prepared by pre-service science teachers for "*Level 4*", one of the PISA science literacy proficiency levels, and examples of questions belonging to the level are given (Table 7).

Table 7: *Level Distributions and Sample Questions Prepared by the Prospective Science Teachers for "Level 4"*

Question Levels	Frequency	Percentage (%)	Student Teacher Question Sample
1b Level	2	6.06	**S18***: ...He cannot remember which type of wave the microwave is and asks his mother. What is her mother's answer?*
1a Level	0	-	-
2 Level	5	15.15	**S20:** *Obesity is the excessive increase in the ratio of the body's fat mass to the lean mass, resulting in an increase in body weight above the desired level according to height. In other words, the daily energy intake is more than the energy expended. ...according to the text, what is the relationship between obesity and diabetes?*
3 Level	6	18.18	***S30:*** *What do you think is the underlying reason why marine pollution negatively affects this food chain?* ***S9:*** *Galileo claimed that he had discovered that Saturn had 2 moons and that these moons together with Saturn formed a triple structure. A few years later he observed Saturn again, but the handles had disappeared from Saturn's circumference. A few years later, he saw the missing handles reappear. How do you explain this?*
4 Level	20	60.60	**S23:** *Although they are closely related, the cell wall structures of branchypodium and wheat plants are different and specific species. What can be said about the reliability of model organisms?* **S29**: *Marble pieces were placed in two containers containing vinegar and water, and the next day the pieces were taken out of the containers and dried. The dried marble pieces were weighed. What is the reason for using vinegar and water in the experiment conducted by the students?*
5 Level	0	-	-
6 Level	0	-	-

Note. 1 teacher candidate has not written questions at level 4.

When Table 7 is examined, the distribution of question levels prepared by pre-service science teachers for level 4 is seen. It is understood that 20 of the pre-service teachers (60,60%) wrote questions appropriately for level 4. It was determined that 6 of the pre-service teachers (18,18%) tended to write questions at level 3 in the preparation of questions at level 4. Following this, it was determined that 5 pre-service teachers (15,15%) wrote questions at level 2 and 2 pre-service teachers (6,06%) wrote questions at level 1b.

In this framework, when the sample question sentences are examined, in the level 4 question prepared ***by the pre-service teacher coded S23***; students are expected to interpret the data on the reliability of model organisms that they are not familiar with. In the context-based text, they are asked to explain the complex situations presented to them about the model organism and justify their appropriate choices. Therefore, it is clear that the question written by the pre-service teacher is appropriate for level 4. The question ***of the pre-service teacher coded S18*** was evaluated at level 1b on the grounds that it was a

question requiring direct knowledge. In the question prepared ***by the pre-service teacher coded S20***, the definition of the concepts of obesity and diabetes was given briefly and the student was expected to establish a basic relationship between the concepts and explain them scientifically. In this context, it is understood that the question level should be at level 2 instead of level 4. The question of ***the pre-service teacher with the code S9*** asks students to explain the situation of the handles that form and disappear around Saturn. The student is expected to explain a system that may seem partially complicated with clues and supports by using method knowledge. When evaluated from this point of view, it is understood that the question is more suitable for level 3.

The level distributions of the questions prepared by pre-service science teachers for "*Level 5*" of the PISA science literacy proficiency levels and examples of questions belonging to the level are given (Table 8).

Table 8: *Level Distributions and Sample Questions Prepared by the Prospective Science Teachers for* "Level 5"

Question Levels	Frequency	Percentage (%)	Student Teacher Question Sample
1b Level	3	10	**S7:** *Give an example of an object that has both kinetic and potential energy.*
1a Level	1	3.3	**S27:** *In which case more than 22 (e.g. 44 panels) can be used for an annual consumption of 11,000 kwh?*
2 Level	5	16.66	**S29:** *Write how we can benefit from science and technology in solving environmental problems (sea and ocean deaths etc.)?*
3 Level	7	23.33	**S4:** *Healthy cells in our body have the ability to divide. Sometimes the process goes astray and unconscious cancer cells begin to divide uncontrollably and multiply. What is the reason for this?*
4 Level	2	6.6	**S3:** *Is gender discrimination important in organ transplantation?*
5 Level	12	40	**S31:** *Is the reason why a raindrop looks transparent while a thick layer of ice looks blue related to reflected photons? Why?* **S33:** *Explain the relationship between electromagnetism and conductivity?*
6 Level	0	-	-

Note. 4 pre-service teachers did not write questions at level 5.

When Table 8 is examined, the distribution of the question levels prepared by pre-service science teachers for level 5 is seen. It is understood that 12 of the pre-service teachers (40%) wrote questions appropriately for level 5. In the preparation of 5 level questions, it was determined that 7 (23.33%) of the pre-service teachers tended to write 3 level questions. Following this, 2 prospective teachers (6,6%) wrote questions at level 4, 5 prospective teachers (16,66%) at level 2, 1 prospective teacher (3,33%) at level 1a and 3 prospective teachers (10%) at level 1b.

In this framework, when the sample question sentences are examined, in the level 5 question prepared ***by the pre-service teacher coded S31***; he explained the absorption and reflection of light, but aimed to question the relationship between this situation and

photons. At this point, he wanted students to explain the complex phenomenon involving causal connections with light photons, which is an abstract scientific concept. He expected them to explain the dark color appearance caused by the movement of light by scientifically evaluating it with photons. Therefore, it is understood that ***the preservice teacher coded S31*** was able to write questions at level 5, which is the targeted question level. The question ***of the pre-service teacher coded S9*** was evaluated at level 1b because it showed that it was directly knowledge-oriented by asking for an example of an object with kinetic energy.

The question of the pre-service ***teacher with the code S27*** was evaluated at level 1a because it was designed to be answered with a contextual text and a simple inference. ***The pre-service teacher with the code S3*** was asked to explain a complex situation regarding the distinction of gender in organ transplantation and to justify their appropriate choices. At this point, the question ***of the pre-service teacher with the code S3*** was included in level 4. In the question ***of the pre-service teacher with the code S4***, she was expected to explain the uncontrolled proliferation of cancer cells by associating it with DNA. he is asked to justify the proliferation of cancer cells with clues and supports using her procedural knowledge. At this point, the question ***of the pre-service teacher coded S4*** was evaluated at level 4. The fact that the question ***of the pre-service teacher coded S29*** aimed to produce valid results at the point of producing solutions to the problems of the environment with science and technology with the help of his/her basic level knowledge supported its inclusion at level 2. The level distributions of the questions prepared by pre-service science teachers for "*Level 6*" of PISA science literacy proficiency levels and examples of questions belonging to the level are given (Table 9).

Table 9: *Level Distributions and Sample Questions Prepared by the Prospective Science Teachers for "Level 6"*

Question Levels	Frequency	Percentage (%)	Student Teacher Question Sample
1b Level	3	10.34	**S2:** *Which of the following does not fall under the heading of precipitation? (Fog)*
1a Level	1	3.44	**S7:** *Briefly define kinetic and potential energy in your own words. State how many types of potential energy and what they are.*
2 Level	2	6.89	**S4:** *One of the methods of treatment of cancer is chemotherapy. The main ways of receiving chemotherapy are: intravenously, in serum, tablets and capsules. Based on this information, explain the mechanism of chemotherapy?*
3 Level	3	10.34	**S30:** *In a shrimp analysis study conducted by Greenpeace Mediterranean, '0.28 micro plastics were found in 2 out of every 10 shrimps.' Accordingly, which conclusions can be drawn from this study?*
4 Level	5	17.24	**S12:** *What are the important effects of physical geography factors in the formation of climate characteristics on earth?*
5 Level	6	20.68	**S13:** *Is it possible to restore biodiversity in a place? If so, in what ways?*
6 Level	9	31.03	**S21:** *This matter-sucking super galactic black hole at the centre of our galaxy is also the centre of a lot of activity. Here stars die and come back to life in an endless cycle. Explain how stars come back to life.*

Note. 5 pre-service teachers did not write questions at level 6.

When Table 9 is examined, the distribution of the question levels prepared by pre-service science teachers for level 6 is seen. It is understood that 9 of the pre-service teachers (31,03%) wrote questions in an appropriate way for level 6. In the preparation of 6-level questions, it was determined that 6 (20,68%) of the pre-service teachers tended to write 5-level questions. Following this, 3 pre-service teachers (10,34%) wrote questions at level 3, 5 pre-service teachers (17,24%) at level 4, 2 pre-service teachers (6,89%) at level 2, 1 pre-service teacher (3,44%) at level 1a and 3 pre-service teachers (10,34%) at level 1b.

In this framework, when the sample question sentences are examined, in the level 6 question prepared ***by the pre-service teacher coded S21***, he made explanations about the galaxy and black hole in the contextual text he wrote. However, he is expected to justify and explain a complex situation of the stars dying in a cycle and coming back to life again without being bound to the text. They are expected to be able to understand the ideas and concepts of space by using their epistemic knowledge about the life process of stars and the nature of a black hole. Therefore, it was deemed appropriate to deal with the information based on scientific evidence and at level 6 on the grounds that the ability to produce information other than what is presented to them was emphasized. The question prepared ***by the preservice teacher coded S2*** can be answered with a simple logical inference that the student can make. The question ***of the pre-service teacher coded S2*** was handled at level 1b on the grounds that he could easily reach the conclusion that fog cannot be evaluated while snow or rain is evaluated under the title of precipitation. When the question ***of the pre-service teacher coded S7*** is examined, the definition of work and energy is given in the text and it is asked to write the definition of kinetic and potential energy types by making inferences with their own expressions. However, although the question was not based on inference, it did not go beyond testing knowledge. At this point, it is stated that the question written ***by the pre-service teacher coded S7*** is suitable for level 1a. The contextual text belonging to the information about cancer and treatment types was given in the question prepared ***by the pre-service teacher coded S4***. However, students are expected to make effective inferences from this information, adapt it to daily life and explain the working system of chemotherapy with the basic knowledge they have. From this point of view, it was not deemed appropriate to include the question at level 6 and the question ***of the pre-service teacher coded S4*** was included in level 2. In the question ***of the pre-service teacher coded S4***, students are expected to interpret simple data about the rate of encountering microplastics, which may seem partially complicated, with clues and support using their methodological knowledge. For this reason, the question was evaluated at level 2 based on the data based on the ratio of plastics without being directly connected to the text. The question ***prepared by the pre-service teacher coded S12*** is at level 4 because students can clarify the result with the clues provided when they are not familiar and cannot obtain the information directly. ***The question prepared by the pre-service teacher coded S13*** was included in level 5 instead of level 6. The question was left within the boundaries of school

life and the student's ability to form hypotheses was put in the background. Similarly, it aims to explain the event or process of an abstract scientific concept in a causal context. In general, it can be stated that the question could not be included at level 6 because it reached the answer without requiring a very high level of interpretation.

Discussion

In this study, it is aimed to examine the context-based question writing skills of pre-service science teachers in an in-depth manner. PISA is shown as an important argument in the process of transformation and implementation of the education process (Aydın et al., 2018). Within the framework of this purpose, the context-based texts created by pre-service science teachers in free subjects and 7 questions belonging to each of the PISA science literacy levels that they wrote in accordance with the text were analysed and evaluated.

The results of the study revealed that approximately half of the pre-service science teachers (56%) were able to prepare questions appropriate to the PISA level. This result can show that pre-service science teachers have the competence to prepare critical thinking and problem-oriented PISA questions. The positive effect of the training on context-based questions, PISA exam, PISA science literacy and PISA level questions given during the research process was proved. It can be said that the pre-service teachers were given the potential to construct context-based PISA level questions with the training provided. In a study conducted, it was determined that pre-service teachers had sufficient knowledge and experience to write questions as an output of the context-based question writing training (Çepni et al., 2020). In the study conducted by Ünal (2019), science teachers stated that after the training, they were able to recognise the questions with PISA image, the questions they developed became more creative and included daily life problems. In a similar study, mathematics teacher candidates were trained about PISA and the exam and it was found that many of the problems that the candidates constructed for the questions were appropriate to the nature of PISA (Şahin & Başgül, 2018). It is possible to emphasise that the results of the study overlap with the point that there will be a significant change in question writing skills with a context-based question writing training given to teachers. It can be said that pre-service teachers who do not prepare context-based questions suitable for PISA level have problems with prejudging such questions, having no prior knowledge and not focusing. In a study that can be parallel to our current study, the capacity of pre-service elementary mathematics teachers to create questions in the PISA mathematics literacy assessment criteria as a result of the instruction given to improve their PISA mathematics literacy levels was also investigated. According to the results obtained from the pre-service teachers, it was seen that there was a significant increase in their PISA mathematics literacy levels as a result of the instruction (Gürbüz, 2014).

It can be inferred that a significant number of pre-service science teachers are still not sufficiently proficient in writing context-based questions. It was determined that pre-

service teachers who were able to write questions appropriate to the level were able to prepare questions at level 1b and 1a correctly. On the other hand, it was determined that they had difficulty with writing level 5 and level 6 questions. Pre-service teachers were able to write 1b and 1b level questions at an appropriate level. It is understood that pre-service science teachers write lower-level performance questions (1b and 1a level) more accurately than higher-level performance questions (5th and 6th level) (MoNE, 2016). At this point, it is clear that pre-service science teachers have difficulties in the process of preparing question levels that require metacognitive thinking skills. It is clear that pre-service science teachers have some deficiencies in writing high-level questions. The research results of Çepni et al. (2020) indicate that science teachers have some deficiencies in the context-based question writing process. Similarly, in another study, science teachers' self-efficacy in writing questions that measure higher-order thinking skills was found to be low (Bolat et al., 2022). In another study, it was determined that teachers prefer questions that require low-level cognitive process skills and generally prefer questions that contain concept knowledge in the knowledge dimension (Yıldırım, 2020). Similarly, it is pointed out that teachers use traditional question types and keep preparing context-based questions in the background. However, it was determined that they advocated the idea of prioritising context-based questions that are short and easy to prepare (Ülger et al., 2022). The studies provide a basis for the results of the current research by emphasising that science teachers are not sufficient in the process of writing high-level context-based questions and that they have some deficiencies. In another study, context-based questions were prepared within the framework of PISA within the scope of science teachers' environmental education course. It has been interpreted that the prepared context-based PISA questions have some deficiencies (Aköz et al., 2022).

Conclusion and Recommendations

The fact that there is not a higher proportion of science teachers who write context-based questions at the PISA level may be due to the fact that the context-based approach is not integrated into textbooks and curriculum content at the desired level. Research supports this view and points to the need for science textbooks to include high-level context-based questions (Al-Rosaa, 2023; Arık Güngör & Saraçoğlu, 2023). Kömürcü & Yenilmez-Türkoğlu (2022) examined the assessment and evaluation questions in science textbooks according to the 6 proficiency levels of PISA science literacy. It was determined that the science textbooks contained the questions at the 1st and 2nd levels and the questions at the 5th and 6th levels the least. It was determined that the rate of questions at the upper performance level was quite low. On the other hand, it was pointed out that curriculum outcomes should be associated with PISA proficiency levels (İşeri, 2019). The results of the research show that the pre-service science teachers did not make a distinction between the writing of questions at level 1b and 1a. This situation shows that pre-service teachers' critical thinking and higher-level cognitive skills development processes should be supported more. Both theoretical and practical applications on how to formulate questions at different cognitive levels should be included more. In addition, examples,

exercises and feedback processes can be increased to clearly show the difference between levels 1a and 1b.

Ethical Approval

Ethical approval and written permission were obtained from the Bartın University Social and Humanities Sciences Ethics Committee (approval granted at the meeting dated 27 April 2023, meeting no. 09, application no. 2023-SBB-0234).

Author Contributions

Kevser ARSLAN: Conceptualisation, Theoretical Background, Methodology, Data Analysis, Data Visualisation, Writing, Review and Editing, Funding Acquisition

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Conflict of Interest

The authors declare no conflict of interest.

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