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Table of Contents

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Nature of Science Conceptions and Identity Development among Science Education Doctoral Students: Preparing NOS Teacher Educators

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Abstract

Research on Nature of Science (NOS) conceptions and identity development for NOS contains a gap in the realm of examining doctoral students aiming to be science teacher educators. This research examines the NOS identity development of participants in a course focused on the philosophy of science and research about NOS education. The data analyzed for this study were recordings and notes taken during class discussions in a NOS seminar, as well as NOS research and teaching assignments associated with the course. These data sources were analyzed for development of four influences on identity development for NOS: 1) personal influences on NOS identity, 2) contextual influences on NOS identity, 3) competing identities with NOS, and 4) persistence in overcoming barriers to development of a NOS identity. Findings emphasize the need to target NOS identity development among teacher educators, as they hold the primary responsibility for instilling a NOS identity in their own students, who are future teachers.

Introduction

Understanding of Nature of Science (NOS) is considered to be a major component of developing scientific literacy (Lederman, 2007), and thus should be considered a necessary outcome of science education. NOS identity refers to educators who have developed a professional identity as someone who not only understands NOS, but can also teach NOS to others (Akerson et al, 2015). In light of the importance of NOS, teachers and researchers have sought to effectively implement NOS in science education at all levels, from early childhood (Akerson, Buck, Donnelly, Nargund, & Weiland, 2011) to university science, both undergraduate and graduate (Koksal & Koksal, 2012; Desaulniers Miller et al., 2017). Despite the wide variety of demographics previous NOS research has focused on, there are few studies examining the NOS conceptions of science education doctoral students. The future role of many science education doctoral students is the role of a science teacher educator, holding the primary responsibility for educating future science teachers about NOS. The purpose of this study was to examine the NOS identity development and NOS conceptions of science education doctoral students from a wide variety of backgrounds. More specifically, the following research questions guided this study:

1. What are the NOS conceptions of science education doctoral students at the beginning of a seminar focused on NOS teaching and learning, and how do those conceptions change by the end of the seminar?

2. How do the varied backgrounds and experiences of science education doctoral students intersect with their NOS identity development in a NOS-based doctoral course?

Although there is not an agreed upon single definition of NOS, these are key aspects that are less controversial and are accepted by scientists, historians, and philosophers and considered as most practical in school settings, and useful in developing scientific literacy for students K-12 (Bell, 2009; Lederman, 1992; Lederman, 2007; Lederman et al., 2002; Lederman et al., 2013). These aspects are as follows: science is 1) tentative, 2) empirical, 3) creative and imaginative, 4) subjective, 5), socially and culturally embedded, 6) not limited to one universal scientific method, and 7) grounded in theories and laws, whose differences are important. Though participants in this study come from a variety of international contexts, we chose to ground in the NGSS-aligned view of NOS because each of the participants is learning to teach in the United States.

Theoretical Framework

It is vital that we as science teacher educators continue to explore the complexities of science teacher identity development. Zembal-Saul (2016) offers that there is a lack of clear definitions associated with science educator identity. Additionally, Kelly (2012) speaks to the deficiency of studies focused on science educator identity that expose cultural experiences where cultural practices afford opportunities but limit potential future identity development. Further, Mensah (2016) challenges the lens of science teacher identity through the intersectionality of race and cultural experiences. When dealing with science educators' identity development, we have to consider the complexities of the teacher. They can be reformed and shaped throughout their careers. This aspect of science teacher identity is foundational to this study, as participants come from a variety of social and cultural backgrounds.

Regarding NOS identity, research has been conducted to develop a framework to identify whether teachers have developed a professional identity as someone who not only understands NOS, but can also teach NOS to others (Akerson et al, 2016; McClain et al., 2022). These characteristics of the individuals include personal and contextual influences, as is noted as important by Beijaard et al (2004). This framework discusses personal factors and overcoming barriers to teaching NOS as aspects of NOS identity, but as we did not follow participants into their actual practice (necessary for examining the influence of these aspects), they are not discussed. Contextual influences and competing identities with NOS were those most prevalent in the data, as they could be discussed and examined without examining actual teaching practice.

Contextual influences include influences beyond the scope of the individuals themselves, but still influence their identities. Support from others is a strong contextual influence, as individuals who are in situations where they are not supported or discouraged from teaching NOS may struggle with developing a NOS identity, as they will question the importance of it. However, those who have support through socially mediated means generally are able to develop a NOS identity. This support can take place through professional development programs, coursework, or communities of practice, for example.

Competing identities could either strengthen or inhibit development of NOS identity. For example, if an individual strongly holds an identity that includes science making progress through controlled experiments via "the scientific method," this individual may find conflict with aspects of NOS, such as science being contextualized in a social and cultural context. This individual may grapple with these discrepancies and it could slow the development of NOS identity. However, if an individual holds an understanding that knowledge itself is contextualized in social and cultural context, they may find relief in learning that scientific knowledge also develops within such a context (and not isolated in a method). This can ease the conflict the individual has with the aforementioned competing identities.

Literature Review

Because participants were doctoral students with backgrounds in science and science education, this review focuses on the NOS conceptions of graduate students. Also addressing identity aspects of developing teacher educators, the existing literature on NOS identity is discussed.

Graduate Conceptions of NOS

Previous research has been conducted on NOS instruction at the graduate level. Graduate students' understanding of NOS was addressed as early as 1997, with Eichinger and colleagues development of a NOS course for science education graduate students. Grounding in their craft knowledge of teaching NOS, the authors discuss the importance of future science teacher educators having a developed understanding of NOS in order to facilitate scientific literacy in their own students (future teachers).

The NOS conceptions of graduate researchers in the hard sciences were examined by Koksal and Sahin (2013). They analyzed questionnaires (VNOS, version C) of graduate researchers from several scientific fields, in order to determine the effectiveness of simply participating in science when it comes to developing conceptions of NOS. They found the participants had expert conceptions on the social and cultural embeddedness of science, and the creative nature of science. However, they showed naive understanding of the hierarchy of theories and laws, and mixed understandings of subjectivity, tentativeness, and the idea that there is not one universal scientific method. The authors conclude that simply participating in science is not sufficient to develop NOS understanding. They recommend explicit-reflective NOS instruction at the graduate level.

Sumranwanich and Yuenyong (2014) examined the conceptions of NOS and attitudes toward teaching NOS of masters students in science education. The course these students were enrolled in engaged them in explicit-reflective NOS instruction grounded in inquiry lessons. They used the Views on Science and Education (VOSE) questionnaire (Chen, 2006) to examine their views of each tenet of NOS, and their attitudes toward teaching NOS. After participating in a course employing explicit-reflective inquiry-based NOS activities, participants displayed mixed conceptions of NOS. Despite these mixed conceptions, however, the majority of participants held positive attitudes toward teaching NOS, particularly the tentative and subjective NOS. However, they also displayed value for teaching one scientific method, rather than the variety of methods reflecting actual scientific practice.

Explicit-reflective methods were also employed by Wheeler and colleagues (2019) in their instruction of STEM graduate students in a higher education course focused on NOS. The course was targeting graduate students in STEM who are often assigned to teach undergraduate science courses. Using the VNOS-C, researchers found NOS conceptions among participants improved substantially from pre- to post-course, especially when it came to the tentative NOS and the hierarchy of theories and laws. Perhaps the most impactful finding was the increased intention to teach NOS from the participants, specifically with explicit-reflective instruction.

NOS Identity

Teacher educator identity development is a critical area of study, as individual teachers are complex, ever-changing, and grounded in individual social and cultural backgrounds (Mensah, 2016). This remains the case as attention is turned specifically to an identity for NOS. This study is framed in NOS identity (Akerson et al, 2015), focused on personal and contextual influences on NOS identity, competing identities with a NOS identity, and overcoming barriers to developing a NOS identity.

Research has shown that even young science students can develop an identity for NOS. In a study of third graders learning about gravity, Akerson et al (2019) found connecting to real-life experiences, discussions as a class, and connecting to other science concepts were all supportive of students' NOS identity development. Development of an identity as a teacher of NOS has been shown to be less than straightforward. As present in the NOS identity framework grounding this study (Akerson et al, 2016), developing a NOS identity requires balancing a variety of personal factors (emotions as identity is formed and reformed) and contextual factors (administrative pressures, time constraints). This characteristic was found in a self-study on NOS identity development conducted by Akerson et al (2015). Ultimately, the development of a NOS identity required balancing a variety of sometimes conflicting sub-identities. Even once one has developed an identity for NOS, it requires continual work to maintain and continue in the development of a professional identity teaching NOS.

Research has examined the intersection of science identity and NOS understanding (Avraamidou & Schwartz, 2021; Celik, 2020; Elcan Kaynak, Akerson, & Cevik, 2020); El Takach & Yacoubian, 2020). Conceptions of NOS will shape individuals' ideas about who can or cannot be a scientist, or who is allowed to participate in science. Embracing a subjective and diverse view of NOS allows for disruption of the traditional view of who a scientist is (white male). Emphasizing the socially and culturally embedded NOS also allows individuals to see themselves as science people, developing a science identity, and more specifically a NOS identity.

Development of a NOS identity does not rely solely on an understanding of NOS, but also individual factors such as beliefs and backgrounds. In a study of the impact of NOS understanding on sociopolitical scientific disagreements, researchers found participants' political and religious views were predictive of whether they would accept scientific claims. However, regardless of political and religious affiliation, individuals with a greater understanding of how science works were more likely to accept scientific claims (Weisberg et al., 2021). What each of these studies shows is that personal factors outside of scientific understanding alone influence development of one's NOS identity. Individual cultures, backgrounds, experiences, and religious/political

affiliations will influence how one perceives NOS. It is with these influences in mind that we examine the development of a NOS identity for developing science teacher educators from a variety of backgrounds.

Method

We use phenomenology as our epistemological framework. Phenomenology rejects that the external world and facts exist independently. Instead, it argues that knowledge is consciously constructed by each individual in interpreting their immediate experience (Groenewald, 2004). Such immediate experiences that are used in constructing knowledge consciously are the "phenomena" (Eagleton, 1983, p.55). In qualitative research, phenomenology can be used to study people's conscious experience of their world; that is, their "everyday life and social action" (Schram, 2003, p.71). Researchers who apply phenomenology in the study are concerned with "understanding social and psychological phenomena from the perspectives of people involved" (Welman & Kruger, 1999, P.189). Phenomenology is appropriate to this study because the purpose of this study is to understand the phenomena of a group of doctoral students' experience of understanding NOS during a course. Phenomenology requires that researchers be aware of their own positionality, beliefs, and assumptions while gathering data that can reflect the perspectives of the participants (Hammersley, 2000). In this study, we use discourse analysis and content analysis as our methods. As we are both researchers and participants, we make our own understanding explicit while analyzing data to get the essence and underlying NOS conceptions and identity development of the doctoral students. Specifically, the components of NOS identity development were used as codes and themes to analyze data sources to further understand participant NOS conceptions and identity.

Context and Participants

The context was a semester-long doctoral seminar with a focus on NOS. The goals were two-fold: to develop doctoral students' ideas about NOS so they can be prepared to teach it, and to establish a foundation in philosophy of science to be able to distinguish philosophy of science more generally from classroom-adapted NOS. It is of note that NOS was defined according to the consensus view presented above, focusing on the agreed-upon aspects most relevant at a K-12 level (Bell, 2009).

Course readings about philosophy of science were anchored in Alan Chalmers book "What is this thing called science" (4th edition, 2013). Additional readings included seminal research in teaching and learning NOS providing an overview of various research trends in NOS. Student coursework included the crafting of individual NOS teaching philosophies as well as NOS lesson plan development and delivery of NOS lessons to peers in the course. Discussions at the beginning and end of the semester focused on participant responses to the VNOS-B (Lederman et al., 2002), which were critical data sources when it came to participants' NOS conceptions. Participants in this study were the doctoral students enrolled in this NOS course. The group represented a variety of backgrounds and a diversity of experiences; participants came from a variety of gender/sexual orientation, cultural, educational and career backgrounds. In light of the personal and context-laden nature of NOS identity development, it is pertinent here to include a brief description of the background of each of the participants of this study. This information is included in Table 1.

Table 1. Background Information on the Participants/authors of This Study at the Time of Data Collection

Participant	Background Information
Andrea	White American female, second year in program, undergraduate degree in biological science education, teaching experience in science labs and student teaching, experience teaching in elementary science field experience course
Shukufe	Bangladeshi female, first year in program, five years experience in non-profit educational organizations, experience in materials development promoting inquiry-based science, and teaching English in China
Qiu	Chinese female, second year in program, undergraduate degree in applied chemistry and masters degree in environmental science, five years experience in public and private high schools in China, experience teaching scientific inquiry course
Claire	White American female, second year in program, seven years experience teaching middle-school science in both suburban and urban schools, informal science education experience, experience teaching elementary science methods course
Conghui	Chinese female, first year in program, masters in ecology, three years experience in informal education, and six months in outdoor science education
Tulana	Sri Lankan gay male, first year in program, undergraduate in chemistry and physics, masters in chemistry, experience teaching undergraduate chemistry and physics
Jessica	African American female, second year in program, masters degree in biology, teaching experience four years in middle school science, experience teaching elementary science field experience course
Valarie	White American female, undergraduate in psychology, masters in elementary education, PhD in science education, professor of science education, 20 years experience teaching elementary science methods and doctoral courses, experience teaching elementary school

Data Sources

Each data source stemmed from the NOS course taken by the participants, and included 1) audio recordings of weekly class discussions about assigned readings, 2) notes from these discussions taken by the instructor (Valarie), 3) a position statement toward NOS teaching written by each participant toward the end of the semester, and 4) a lesson plan prepared by each student with the goal of teaching NOS tenets. For the purpose of brevity in reporting the source of data excerpts, the abbreviation DR indicates the excerpt comes from a discussion recording, the abbreviation NPS indicates a NOS position statement, the abbreviation IN indicates instructor notes, and the abbreviation LP indicates a prepared lesson plan. The number following the abbreviation indicates which class session is being referred to.

Data Analysis

Concepts related to NOS identity were used as *a priori* codes to apply to each of the data sources. Specifically, artifacts were broadly coded for 1) participants' value for NOS or lack thereof (related to personal factors and competing NOS identities) 2) discussion of NOS curriculum, assessment, and difficulties related to teaching NOS (related to contextual factors). Additionally, discussion of NOS content was identified to determine the development of participants' NOS conceptions over the course of the semester.

The coding process for this study varied depending on the data source. For the recordings of classroom discussions, researchers listened to the discussions, and when discussion relevant to NOS identity development or NOS conceptions, the researcher recorded the statement/conversation block, time, and the participants speaking. For written data sources (Instructor notes, NOS lesson plan, NOS position statement), researchers read the document, and blocked out areas of text relevant to NOS identity development or NOS conceptions. Each data source was coded by two researchers, who then met to reconcile their coding to reach agreement.

Results

Addressing the first research question focusing on participants' NOS conceptions, these findings will discuss participants' conceptions of NOS at the beginning and end of the doctoral seminar on NOS. Addressing the second research question on the participants' NOS identities, findings are then organized in accordance with the aspects of an identity for NOS framing the analysis: 1) contextual influences on NOS identity, and 2) competing identities with a NOS identity. The aspects of the Akerson et al. (2016) NOS identity framework pertaining to personal influences on NOS identity and overcoming barriers to teaching NOS were not included in this analysis, considering the fact that data was not gathered on participants' actual teaching of NOS–data had more reference to participants' perceived contextual influences on NOS identity, and on existing identity factors that may or may not conflict with a NOS identity.

NOS Conceptions Early in the Semester

Despite being actively involved in different roles in science education, most of the doctoral students in the course had never heard of NOS formally or informally prior to beginning the doctoral program. Claire was the exception, having taught NOS previously to her middle school students, though she never had formal training on NOS or NOS instruction (Claire, DR1). This did not exclude them from seeing the value of NOS. Andrea mentioned her views had drastically changed, and she became aware of aspects of science not previously on her radar (Andrea, DR7).

As the course progressed and participants became more familiar with NOS through readings and discussions, Shukufe doubted the role of creativity in the nature of science. Specifically, she wondered what makes creativity specific to science when all jobs are done by people and are therefore creative (Shukufe, IN4). Conghui agreed

that all jobs include creativity, but scientists must be creative while still being grounded in evidence (Conghui, IN7). Questions and discussions about these ideas aided in developing understandings about NOS aspects.

When it came to the socially and culturally embedded NOS, various ideas were brought up over the course of the semester relating to emotions. Jessica, who held a strong resonance with socioculturally embedded NOS, stated that all aspects of NOS were important, despite not being taught, and that that social and cultural backgrounds would influence scientific interpretations (Jessica, DR7). Claire strongly believed that the tentative NOS should be emphasized because science changes, is emotion-driven, and is socially and culturally embedded. Qiu agreed that there is emotion in science, but that emotion is not visible in a scientific paper. She believed that the inclusion of emotion was not a weakness, but a part of the creativity of science, and partly why science is based on subjectivity (Qiu, DR4). Tulana also noted the role of subjectivity, commenting that given his background, he tends to think through the lens of chemistry, showing his realization of his own subjective understanding (Tulana, IN7)

In reference to the tentative NOS, Andrea mentioned that it may be less likely for students to notice that scientific knowledge is tentative because the scientific ideas and theories taught at the K-12 level are not likely to change (Andrea, DR7). Most scientific change occurs at the cutting edge of science, so the idea of tentative NOS needs to be pointed out to students when it comes to scientific theory. Claire noted that NOS and inquiry are connected, but that you can teach inquiry without focusing on NOS; ideas need to be pointed out to students explicitly for NOS and inquiry to be intertwined (Claire, DR1). In most if not all situations, the doctoral students addressed the need for explicit instruction of NOS concepts.

NOS Conceptions at the End of the Semester

Below, we describe some of the final ideas about NOS that were shared in the class. These final ideas came from the discussion of questions making up the Views of the Nature of Science Survey, Version B (VNOS-B; Lederman et al., 2002), and thus gave insight into participants' NOS content knowledge development. All data shared in this section come from the discussion seven recording (DR7).

Regarding the tentative NOS, at the end of the semester participants discussed question 1 of the VNOS-B on whether theories change. Andrea said that theories change based on new evidence, or new ways of thinking about the evidence we have. We need to teach theories because they're the best tools we have, and even if they might change later the changes will likely be based off of what we already had. Additionally, the theories we teach at a K-12 level are in all likelihood not going to change. Qiu agreed and said that in chemistry we still need to teach students the theories so they can learn and perhaps add to the theories. Andrea pointed to the role of theories as a means of teaching the tentative NOS. Claire agreed that teaching the tentative nature of scientific theories combats the idea of science as a set of facts. Tulana discussed that his conceptions of scientific theories have changed over the course of the semester, and shared that just because we learn new things doesn't mean we have to disagree with what we knew before. Theories just become more sophisticated, and more generalized. Conghui added that the process of theory change is very slow, and if we don't know the currently accepted theories we may not be

able to do further research and know what has already been ruled out by the scientific community. Therefore, participants conceptualized that scientific knowledge can change, and yet we need to understand the current knowledge base as it is explanatory now and can help develop new knowledge.

Next, participants discussed observation and inference, specifically whether you have to "see" something to draw conclusions about a scientific idea. Andrea shared Rutherford's experiment to say that we can't necessarily see atoms, but we can infer things about them based on how we interact with them. Therefore, observations can be indirect. Qiu added that it's hard to understand things like how Newton's laws of gravity don't necessarily apply at the atomic level. Instead, we need a new way of thinking in a microscopic world. Andrea added that theoretical physicists can't see anything they are studying; all they know is based on past theories. Claire agreed, and brought up the role of technology in making things "studiable" and helping us rely on theory a little less the more technology advances. "Technology solidifies, or helps us advance, or helps us accept theory" (Claire, DR7). Therefore, participants understood that there was a relationship between observation and inferences, and how observations did not need to be direct for scientists to make reasonable inferences (and that those inferences could change.)

Regarding the distinction between scientific theory and laws, Andrea stated that laws describe what happens, theories describe why, and there may be multiple theories associated with any given law. Andrea and Qiu described how the law of gravity was a good explanatory law with no widely accepted theories. Qiu and Claire asked toward the end of the semester, when a new idea is found and stated, does it matter whether it is a theory or a law? They stated that laws have to be conditional, only applying under certain conditions. This question raised at the end of the semester may indicate that some students held continued misconceptions regarding the type of knowledge that creates scientific laws versus scientific theories.

Participants further explored the role of empirical evidence, and creativity and imagination in science. Claire stated that both art and science involve creativity; art and science are similar because of an aesthetic element, appreciating beauty in our world. Tulana shared that he thought art and science were different because art is more emotionally driven than science. Andrea, Claire, and Jessica thought that science was also sometimes emotion-driven. Qiu believed that science is portrayed as very non-emotional in research publications, which could lead people to believe that science does not include emotions. Andrea shared the idea that anywhere there is subjectivity there is emotion, and because science is partially based on subjectivity there is emotion involved. We are able to see emotion in art, but not necessarily in science. Conghui stated that science and art differ because art is personal, while collaboration is more important in science. Andrea compared art and science in the respect that both have accepted rules and conventions; what makes good art is agreed upon, and what makes good science is agreed upon. She stated that she was coming up with fewer differences between art and science than at the beginning of the semester. Claire followed up with "yeah, art can be collaborative, too" (Claire, DR7). At this point in the discussion the course instructor, Valarie, raised the question, "What about evidence? Does art require it? For me that's the main distinction. Everyone is creative, but science requires evidence for argumentation" (Valarie, DR7). Participants didn't really respond to the question, but continued talking about creativity, which could indicate a need for more emphasis on the empirical NOS.

Regarding differences between scientific fact and opinion, Andrea stated that there was a difference between fact and opinion, but science does have subjectivity in its interpretation. Qiu shared that interpretations will change based on opinion depending on what is valued. She felt this was especially true in politics, where people interpret the same data differently depending on their political view. Claire said that we can have opinions based on evidence, and opinions based on emotion. Shukufe thought that opinion comes into play when we are trying to convince others with and about scientific claims. Conghui raised a question: "We say there are different opinions from the same data, but when does this become knowledge? How do we differentiate between scientific knowledge and opinion (Conghui, DR7)? The course instructor responded "seeing it as regular opinion versus scientific opinion based on evidence. For example, vaccine fear. Regular opinion doesn't have to have evidence, but a scientific opinion would require evidence that the vaccine works" (Valarie, DR7). Qiu stated, "couldn't there be different scientific opinions based on the same evidence? Like the nature of light" (Qiu, DR7). Claire responded with her idea that there could be different opinions on some science like medicine--you may have your opinion on medicine but that might change when you are sick. She stated, "it's a privileged point of view to have certain opinions when you're healthy. Eastern medicine works for some people even where it isn't supported by science" (Claire, DR7). This was followed by a lively discussion which included ideas about scientific evidence and subjectivity in interpreting data, indicating a growth in participants' understanding of these ideas.

Regarding the social and cultural influences on scientific interpretations, and why scientists may make different interpretations of the same data, Claire stated that it is possible for different scientists to interpret universe data differently depending on the theory they subscribe to. Tulana elaborated, stating that different scientists have different background knowledge and ideas that come into play when interpreting the same evidence. Claire agreed, stating that an element of creativity played a role here. Qiu shared that NOS is based on a western science system, that NOS itself might vary in Eastern or African theories of the world, and that cultural background plays a role. Claire agreed, stating that there is a role for both subjectivity and sociocultural influences.

Contextual Influences on NOS Identity

Despite being actively involved in different roles in science education, most of the doctoral students in the course had never heard of NOS formally or informally prior to beginning the doctoral program. Claire was the exception, having taught NOS previously to her middle school students, though she never had formal training on NOS or NOS instruction (Claire, DR1). Though all participants had strong science backgrounds, most held no prior conceptions of the aspects of NOS addressed in the course. This did not exclude them from seeing the value of NOS. Andrea mentioned that her views had drastically changed, and that she became aware of aspects of science that had not previously been on her radar (Andrea, DR7).

During the semester, the doctoral students had a variety of readings and discussions about different aspects of NOS. As they were becoming exposed to the aspects of NOS, they raised questions regarding the meanings of some of the aspects, especially the more nuanced meanings. Prevalent in course discussions across the semester was the need for more curriculum and assessment materials for NOS instruction, and the need for improvement of what is already used. The remainder of this section is more representative of *ideas* that came out of course

discussions and participant data sources than necessarily representing emergent findings. This section is divided into three further sub themes of ideas that came from data sources, focusing on 1) the lack of resources for teaching NOS, 2) the need to embed NOS explicitly in curriculum to facilitate conceptual change and understanding, and 3) the need for NOS assessments that are culturally relevant and aligned with instructional practices. Each of these ideas relate to contextual influences on NOS identity development, or things teachers may struggle with as they attempt to teach NOS.

Lack of Resources

Resources are critical for teachers to implement effective science teaching, and the resources for NOS instruction are scarce. Teachers would benefit greatly from NOS-embedded texts, trade books, activities, lesson planning ideas, and aligned assessments. The research that exists when it comes to resource development has shown some success. Andrea discussed a study examining the development of trade books to facilitate teacher learning and teaching of NOS without the need for professional development (Brunner & Abd-El-Khalick, 2020). She discussed the benefits of making NOS cross-disciplinary and more accessible to teachers, placing science in other subjects (DR1). Participants also discussed the potential benefits of software development to help teachers facilitate students' understanding of NOS (DR2).

One participant in particular, Shukufe, discussed in depth the role of curriculum, specifically textbooks, in facilitating learning of NOS. She said,

> "when such materials have been produced it will be possible to set about systematically developing students' understanding of NOS with a high probability of success. I believe that until such a time as these materials exist, one of the most important objectives of science teaching will largely fail to be achieved" (Shukufe, NPS)

Another major issue with science teaching curriculum materials is that the scientific method is still widely taught where NOS should be. Claire mentioned her experiences looking for science teaching materials in online stores, only to find there were few materials available, including a scientific method poster (Claire DR1) Jessica concurred, stating that teachers needed more resources to encourage and facilitate NOS teaching and learning (Jessica, IN1).

Explicit and Subject-Embedded NOS Curriculum

Conceptual change and understanding in science education would be enhanced with a NOS curriculum that is both explicitly taught and embedded in the subject matter. Textbooks, for example, should contain embedded NOS concepts. Shukufe again pointed out the need for instructional curriculum that mimics student ability to uptake NOS tenets (Shukufe, DR1). Shukufe, Claire, and Conghui discussed the need for materials that could be integrated with existing curricula, perhaps in the form of a NOS book or curriculum that could be used across grade levels (DR1). Some participants discussed the need for better and more curriculum materials in their position statements on NOS teaching. Conghui referred to NOS understanding of preservice teachers specifically when

she said, "I believe NOS should be a part of the current curriculum and combined with science content to constantly challenge preservice teachers' view of and develop better understanding of NOS" (Conghui, NPS). Tulana discussed the benefits of a historical approach to NOS curriculum when he said, "historical evidence is a good avenue for embedding NOS into the curriculum. I am hoping to make an activity to let them understand NOS using historical evidence" (Tulana, NPS).

Creating textbooks including NOS are critical to the creation of a holistic science curriculum. The participants discussed the fact that you cannot "cookbook" NOS (in other words, go through the motions of what NOS is without effective application or critical thinking), because doing so is too surface-level and general (DR2). Shukufe elaborated on this point in her NOS position statement, stating,

> "I think textbooks are an influential component, as they greatly influence the content taught. The textbook is accepted as the ultimate source of knowledge, provides the majority of instructional support beyond the teacher, and in many cases actually becomes the curriculum" (Shukufe, NPS).

In light of the critical role textbooks play in curriculum implementation, NOS should be included in these textbooks to ensure its implementation into science instruction.

Culturally Relevant NOS Assessments

Assessment should be adequately aligned with class instruction, and take into account culturally-relevant science practices. Assessing NOS is difficult in light of the variety of cultural backgrounds that influence how science is perceived. It is also difficult to differentiate understanding from memorization without an in-depth teacher understanding of NOS and how to assess it. Indeed, teachers' confidence and PCK for NOS instruction would ideally involve deeper dives into science content and application for both themselves and their students. This kind of instruction is more difficult to assess in certain contexts, especially if the teachers themselves are unsure about the content or the application of NOS to that content. Assessment has been shown to be a limiting factor for development of PCK for NOS for elementary teachers, even if they have a strong orientation toward NOS (Akerson, Pongsanon, Park Rogers, Weiland, & Galindo, 2017). Qiu discussed NOS assessment in the scientific inquiry course she was teaching at the time of data collection, where NOS knowledge was assessed via a multiple-choice exam. After taking the NOS course, she did not feel this was the appropriate way to assess NOS in the course (Qiu, DR3)

NOS assessment needs to take into account the cultural context of those being assessed. Qiu once again brought assessment into the course discussions by discussing whether different versions of NOS questionnaires may be needed for research purposes based on differing cultural backgrounds and experiences. Valarie agreed, but mentioned the need for commonalities to allow for comparison (Valarie DR7) Participants discussed this further with the idea that NOS ideas are based on a western science system. Others around the world have different ways of thinking about science; different cultures may influence peoples' ideas about NOS. Researchers need to be careful using a western scientific approach and value system to measure against a potential different scientific approach and value system (IN7).

Competing Identities with NOS Identity

Participants in this study held different views of science education, and thus had different beliefs about NOS, due to differing background careers and cultural experiences. First-year participants from an eastern context were more hesitant when it came to embracing a NOS identity. Shukufe doubted NOS would be accepted in her context of origin, stating, "in my country we would have to convince them that knowing NOS is important" (Shukufe, IN7). Despite doubting the applicability of NOS in a Bangladeshi context, Shukufe discussed the benefit of "presenting NOS within the context of inquiries and [scientific] processes" (Shukufe, NPS). She believed the issues with NOS acceptance in an eastern context could potentially be overcome by embedding NOS in the curriculum used by teachers. "This involves restructuring science teacher education programs in a way to promote reconsidering the curriculum in a way that allows and promotes the learning of science and its nature in a meaningful way" (Shukufe NPS). Tulana also hesitated to embrace NOS, stating

> "as a person who studied hard sciences, I had very limited exposure to NOS in my life. When I started studying NOS, I was struggling to understand the outcomes of this (that may be because of my cultural and social background). I am understanding slowly what the use of this is and still exploring" (Tulana, NPS).

Tulana doubted the role of NOS when it came to its connection with his experiences in science. "After I started learning NOS, I started to question the science I learned. However, as a person who had enough exposure in science, I can still maintain my faith in science while learning NOS" (Tulana, NPS). This dissonance Tulana felt between NOS and science as a practice led him to initially believe NOS should not be introduced to young students, before they have had much content exposure (Tulana, NPS). This belief shifted over the course of the semester due to exposure to course readings on effective NOS instruction. "I would agree that NOS must be taught explicitly to anybody despite their age" (Tulana, LP). Participants from an eastern context had much to contribute when it came to how science is perceived differently from their context. Qiu, Conghui, and Tulana discussed how social expectations and culture affect personal choices about choosing science as a career, especially when it comes to women who may be encouraged in some cultures to focus on family roles over career roles (DR4). This idea provides support for the idea of NOS as socioculturally embedded- who practices science is highly influenced by contextual factors.

Overall, participants holding an eastern cultural identity felt dissonance with a NOS identity, expressing that their previous experiences and cultural contexts were in competition with a value for NOS. However, they came to believe those barriers to NOS in their cultural contexts could be overcome, perhaps indicative of their ability to overcome barriers to teaching NOS.

Other participants readily embraced NOS, displaying an identity embracing NOS in science instruction. Jessica embraced NOS for its benefits when it came to scientific literacy, pointing to the need for explicit NOS to support student attainment of science content and literacy (Jessica, NPS). Qiu also discussed the importance of explicit-reflective NOS, specifically in the context of inquiry activities, to help students reflect "not only about the science content knowledge, but also NOS that related to the content knowledge and their daily life" (Qiu, NPS). Qiu

specifically valued NOS instruction embedded in inquiry activities. It is of note that Qiu differed from other participants in an eastern context in her immediate value for NOS. This is likely due to her having a year of the doctoral program completed at the time of data collection, including opportunities teaching about NOS in an inquiry course. The other three participants from an eastern context were just beginning the program, and did not have these experiences to draw from yet. In other words, her identity prior to beginning to the course was more conducive to acceptance of NOS.

One participant's identity for NOS was already established at the time the course took place, having learned about and taught NOS in a middle school context before entering the program. "I feel like middle school is prime time for NOS" (Claire, IN4). She discussed her experience cutting the scientific method poster on the wall into its constituent pieces and rearranging it with her students, discussing the many shapes and methods science can take. Claire's background experiences and exposure to NOS contributed to a clear NOS teaching identity.

The influence of background experiences on NOS identity was apparent in a conversation about the roles of science and religion as epistemologies. This discussion began with the role of science as an epistemology. Participants pointed out the differences between eastern and western practice in medicine, and what is based in science and what is not (DR4). Conghui raises the question "what can be accounted as science?" (DR4) Participants recognized the role that culture plays in how science is practiced, and what methods are employed. Ideas around the role of culture in science practice and perception gave way to a discussion about different ways of knowing and how they relate to science. Jessica pointed out that people from different cultures have different values, and different ways to "make sense" of things (Jessica, DR4). Andrea and Claire expanded on this idea, pointing out that individuals may have different ways of knowing for different aspects of life. For example, one may employ science in their academic work, but have religious beliefs, and those ways of knowing can coexist (DR4). Qiu took a stance that science and religion are to be held separate, stating "we can have multiple boxes to be in. When I do science, I am in the box of science, when I do religious stuffs, I am in another box" (Qiu, DR4).

The participants came to the conclusion that employing multiple ways of knowing, such as religion and science, are necessary to answer all of the questions life presents us with. Andrea pointed out the necessity for allowing for multiple ways of knowing with the statement, "You can't put science in a box, you can't put God in a box" (DR4). These ideas are summarized well by Tulana with the statement, "I think you really limit yourself as a person intellectually and spiritually and academically if you limit yourself to one epistemology" (DR4). These ideas and comments communicate the strong influence that participants' backgrounds had on their perceptions of science and its role as a way of knowing, also illustrating the sociocultural embeddedness of science as represented by NOS.

Influences on NOS Identity Development

By the end of the semester, most participants held a value for NOS as an important outcome of science education, and those who were still hesitant held more value for NOS than they had early in the semester. The final meetings of the course were focused on why participants valued NOS; why is NOS important?

First, participants valued NOS for its benefits to teachers and students when it came to science understanding. Claire and Jessica discussed the benefits of NOS to teachers specifically. Jessica discussed how NOS helps practitioners take research into practice, especially for teachers with limited content knowledge (DR5). Claire discussed how NOS makes science accessible to science educators to help students apply the knowledge in their daily life (DR8). Other participants focused on the benefits to student understanding. Andrea took the perspective of NOS contributing to student scientific literacy specifically. "NOS is important because it is important for students to walk away from my classroom understanding what science is and how science works" (DR8). Many participants specifically mentioned the need to begin teaching NOS early. Shukufe mentioned the difficulty of changing conceptions of science once they are already formed (DR5). Qiu stated "it is hard to say which student will become a scientist and which will not. However, NOS does help the student know science better and probably turn them into a science path. So, NOS education should be for everyone" (DR8).

Second, participants valued NOS for its congruence with their experiences in science. Andrea stated, "having a science background, NOS made perfect sense, it clicked, of course this is how science is and how we should teach science" (DR5). Shukufe also stated that her science background helped her connect to NOS (DR5), while others pointed to a lack of science content understanding potentially leading to difficulties accepting NOS (Tulana, Shukufe, DR5). Conghui pointed out that NOS can help scientists think more critically and make progress in challenging existing ideas in science (DR8). Interestingly, despite pointing out the clear congruence between the practice of scientists and aspects of NOS, when asked who NOS is most important for, Andrea and Tulana answered that NOS is more important for those who do not go into science to make better and more informed decisions as citizens (DR8).

Third, participants valued NOS for its sociocultural aspects. Jessica in particular held sociocultural approaches in high regard, and discussed this aspect of NOS often. "It is really important to consider the context when we teach NOS. The social and economic underrepresented students in the US do not have many opportunities to learn NOS" (DR8). She pointed out that the sociocultural embeddedness of NOS is discussed less than other NOS tenets, and needs more attention (DR8). Others pointed to the importance of the connection of science to personal lives. Shukufe said, "How to make science applicable in my life is more meaningful to me than the content knowledge. Maybe NOS can help us to see science in other ways" (DR8). Similarly, Qiu pointed out the benefit of learning about the philosophy of science throughout the semester when it came to connecting science to humanity. She said it helped to see scientists as humans with stories and difficulties, allowing us to have a better understanding of what factors contributed to their findings (DR5).

Discussion and Conclusion

Most of the doctoral students (except Claire) had never heard of NOS prior to the science education program, despite strong backgrounds in both science and science education careers. This provides additional support for the fact that NOS knowledge is best obtained through explicit instruction; implicit instruction relying on participation in science practices is insufficient for gaining knowledge of NOS (Khishfe & Abd-El-Khalick, 2002). During the semester, through a variety of readings, discussions, and activities, their NOS content knowledge was

growing. In all cases, discussion of NOS was explicit and reflective as the tenets were discussed. Participants were able to increase their understanding of NOS regardless of their cultural background, aligning with previous studies that have shown growth in NOS conceptions around the world (Cil, 2014; Örnek, 2014; Erduran et al., 2020). Although they had good discussions of all aspects of NOS, some aspects received more attention than others. Creativity, social and cultural factors in science, and tentativeness raised some lively discussion both during and at the end of the semester. During these discussions, they explored the more nuanced meanings of some aspects (e.g. creativity in science).

Participants' development of a NOS identity seemed to be independent of their previous career experiences; it was not dependent on whether they had a stronger background as a scientist or a science educator when it came to personal and contextual factors. Rather, their value for NOS instruction varied based on their cultural background, or competing identities with a NOS identity. Previous research has established the sociocultural and tentative NOS, including the idea of theoretical descriptions of NOS themselves being subject to change (Lederman & Lederman, 2014). This study establishes the role of cultural backgrounds when it comes to accepting NOS as a necessary outcome of science education--depending on the background of the teacher or teacher educator, this value for NOS is not a given. Cultural experiences, specifically the role of religion and science as varying epistemologies, seemed to bear equal influence for participants from both eastern and western contexts, reaching the general conclusion that religion and science do not need to be considered at odds with one another, but rather different ways of knowing (Avraamidou & Schwartz, 2021).

Regardless of where they ended when it came to NOS identity development, each participant held more value for NOS instruction at the end of the course than the beginning. First, they valued the greater scientific understanding engendered by increased knowledge of NOS. The benefits to critical thinking (Yacoubian & Khishfe, 2018) and scientific literacy (Dani, 2009) that NOS provides were valued by the participants. Second, participants valued NOS because they saw its alignment with their own experiences with science (Schwartz & Lederman, 2008). Third, participants valued the sociocultural aspect of NOS, finding this particularly relevant to their own practice as science educators. Participants valued the opportunity to make science accessible to all by taking their social and cultural backgrounds into account.

Those with less experience in the program also happened to be from an eastern cultural context, and their concerns about teaching and learning NOS seemed to be related to their experiences in a different context, thus representing a contextual factor hindering NOS identity development. The context of students is critical to take into account when teaching any science content (Hofstein et al., 2010), and NOS is no exception (especially in light of the sociocultural embeddedness of science). Participants from an eastern context were hesitant to embrace NOS instruction, but this was only as they reflected on their own context and brought that knowledge to the table as they discussed NOS.

Contextual restraints on teachers' NOS identity development was a frequent topic of discussion throughout the course. In many cases, teachers rely on the provided curriculum to structure and enact their science instruction (Chiappetta et al., 1987). Where NOS-embedded curriculum materials are not available, it may be difficult for

teachers to successfully implement explicit-reflective NOS learning in their curriculum. Providing NOS materials for teachers to use, whether that be NOS-embedded activities or entire curricula, may be a critical step for teachers to implement NOS in their classrooms, especially with the need for continual professional development when it comes to NOS instruction (Akerson & Hanuscin, 2007). Professional development is not always an option depending on the availability of teacher educators, funding, and/or teachers willing to participate due to constraints on their time or other factors.

These findings point to the importance of targeting NOS identity among science education doctoral students. Most participants entering the science education doctoral program had never heard of NOS. Science teacher educators hold the primary responsibility for educating preservice teachers when it comes to NOS and implementing NOS instruction into their future classrooms. To effectively implement NOS instruction among preservice teachers the teacher educators teaching them must also value NOS as an outcome of science education, and have implemented NOS into teacher education courses, all evidence of a NOS identity (Akerson, Weiland, & Elcan, 2015). This is not a given. Doctoral programs have the prerogative to address NOS identity among future teacher educators to ensure the value for and understanding of teaching NOS is present.

Considering the lack of widespread availability of professional development programs, teacher education programs provide the prime opportunity to instruct preservice teachers on NOS and its importance to their science teaching. Through targeted methods courses and field experiences, preservice teachers can be given the opportunity to practice NOS instruction for themselves (Akerson, Buzzelli, & Donnelly, 2010). Not instilling the importance of NOS during their teacher education experience is, ultimately, a missed opportunity.

Recommendations

From our study we have found that context matters in teaching and learning NOS. In teacher preparation programs we need to consider how to relate NOS to preservice teachers' experiences in different contexts, and prepare them to teach NOS across contexts. As part of the context, culture plays a large role in development of NOS understandings. Relevant research, curricula, and instructional strategies will support NOS development. As such, it would be important to focus on NOS conceptions globally, and ensure curricula around the world include NOS content for K-12 science learners. Science educators could focus on developing such curricula which would be helpful. Future considerations for graduate students and NOS instruction could be to learn how explicit and reflective instruction of the sociocultural aspects of NOS can facilitate deeper global perspectives and personal connections in science epistemology. Research that centers on intersectional identities and NOS identity development is important as we strive to support all learners at all levels in developing scientific literacy.

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Teachers' Effective Use of Time in Scientific Inquiry Lessons

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Abstract

This study was aimed to calculate teachers' effective use of time in scientific inquiry lessons. The research was designed as a case study. The study group of the research consists of 5 pre-school teachers determined by the convenient sampling method. Before the study, the participants were taken in-service training program on scientific inquiry. A timetable, developed by the researchers, was used as a data collection tool. The tool consists of two main themes, "academic time" which has three sub-themes, and "non-academic time". The academic time definition for this research is the process of scientific inquiry interventions that are consist of "building on ideas", "supporting investigation", and "supporting analysis and conclusion" sub-themes. Teachers' classroom videos were the data source of the research. Each video was analyzed in terms of the timetable by the authors. Results of the study stated that the teacher, who uses too much time in one process of the scientific inquiry, could not take enough time to the other processes. In conclusion, teachers need development in the effective use of time in their classrooms. For future studies, it is suggested that mentors' observation and feedback will contribute to the teachers' use of effective time in their scientific inquiry lessons.

Introduction

Teaching is a difficult profession that requires serious preparation and effort to prepare and plan the activities to be carried out in the classroom (Moore, 2001). Teaching is a planned and purposeful by nature and it needs to address the needs of the students. The act of teaching is done by adhering to certain plans; therefore, planning is vital for efficient teaching (Jacobsen, Kauchac & Dulaney 1985). The teachers plan for their classes in advance, teach the lesson in line with this plan, and finally, evaluate the class. Therefore, in evaluating the effectiveness of teaching, the pre-class, the in-class, and the post-class phases should be taken into consideration (Moore, 2001).

The main subject of focus of this study is teachers' use of time during science activities. It is imperative to determine the conditions and situations that cause teachers to have difficulty or lose time in implementing the fundamentals of scientific inquiry in science lessons. Even in well-thought-out classes, teachers may be unable to carry out the designed activities efficiently. The common perception among teachers is that scientific inquiry-related activities take up a lot of time (Campbell, Zhang, & Neilson, 2011; Cheung, 2007). Many teachers complain about being unable to carry out their activities during class, and one of the prominent underlying limitations is argued to be the constraint of time (Jones, Gott, & Jarman, 2000; Staer, Goodrom, & Hackling 1998). Deficiencies in curriculum planning may lead to the inability to spare enough time for all stages of scientific

inquiry (Akuma & Callaghan, 2018). In inquiry based activities, students require additional time to plan their own experiments, collect and data, and reach a conclusion (Cheung, 2007). Accordingly, while planning inquiry-based activities, teachers need to dedicate enough time for students to hypothesize, and collect and analyze data. The knowledge, skill, and experience levels of teachers are bound to affect the plans they make.

In order to ensure the professional development of teachers and enable them to improve their skills, the Ministry of National Education of Turkey provides in-service training during seminar periods. Although in-service training programs are considered a standard procedure, European Commission Eurydice analyzes and the OECD report show that the participation of Turkish teachers in professional development programs is limited (European Commission, 2018; Organization for Economic Cooperation and Development [OECD], 2009). The effectiveness of such training programs are diminished as the same programs are offered to all teachers intermittently and without taking into consideration their personal traits, strengths and weaknesses, and in a way that the teachers are the learners rather than contributors (Oguz Unver et al., 2021). It is necessary to provide teachers with support and opportunities to improve continuously (Taitelbaum et al., 2008). It will be wishful thinking to believe that teachers who cannot improve themselves sufficiently can instruct students in a neoteric and internationally-agreed-upon manner. The PISA (Programme for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study) test scores can be used to extract evaluations on the issue. Accordingly, the Turkish students' science scores in PISA held in 2018 (MEB, 2019; OECD, 2019) and TIMSS held in 2019 (Mullis, et al., 2020) in comparison with students from different countries are presented in Table 1.

Table 1. Comparison of Turkish Students' PISA (2018) and TIMSS (2019) Science and Mathematics Scores with Students from Other Countries

	TIMSS				PISA	
	4th Grade Science Scores		8th Grade Science Scores		15-year-olds' Science	
	Rank	Points	Rank	Points	Rank	Points
Turkey	**19**	**526**	**15**	**515**	**39**	**468**
B-S-J-Z (China)	-	-	-	-	1	590
Singapore	1	595	1	608	2	551
Macau (China)	-	-	-	-	3	554
Hong Kong	15	531	17	505	9	517
Taiwan	5	558	2	574	10	516
South Korea	2	588	4	561	7	519
Russia	3	567	5	543	33	478
Japan	4	562	3	570	5	529
Finland	6	555	6	543	6	522
US	9	539	11	522	18	502
TIMSS Scale Midpoint	-	**500**	-	**500**	-	-
PISA Scale Average	-	-	-	-	-	**458**

It is seen that Turkish students received above-average science scores both in PISA and TIMSS. The improvement in science literacy competencies, namely explaining phenomena scientifically, evaluating and designing scientific enquiry, and interpreting data and evidence scientifically (MEB, 2019), should be a sustained one. Improving

teachers' competencies through in-service training program will affect the way they design in-class activities. In-service training success is contingent upon whether the training is on an area teachers need to develop themselves and whether it is compatible with the relevant curriculum (Capps, Crawford & Constas, 2012). The failure to determine teachers' scientific inquiry-related needs is a significant problem undermining the implementation of a research and inquiry-based curriculum (MEB, 2018). Accordingly, it is imperative to promote teachers' strengths and provide them with support in eliminating their weaknesses.

The main purpose of this study is to examine teachers' use of time in science classes. It was observed that teachers commonly think that inquiry-based in-class activities take too much time (Deters, 2005). There is a need to examine scientific inquiry techniques in terms of time management and detect the problematic variables. Classes are systems encompassing many variables such as the teacher, students, classroom, curriculum, time management, etc. Here, the teaching environment should be directly observed variable by variable, and how time is managed during inquiry-based activities should be determined. Detecting the issues in time management during such activities requires a thorough approach. Literature review showed that the variable of scientific inquiry that challenges teachers the most is time management. Therefore, it is necessary to analyze how teachers utilize the average 40-minute class period. The study will contribute to the literature in terms of the evaluation of teachers' use of time in science lessons, which will potentially be of great use in designing in-service training programs.

Method

The qualitative case study method was adopted in this study. According to Merriam (2009), the case study method helps to examine from a holistic perspective variable such as environment, individual, process, or event related to single or multiple situations. In cases where the case study method is adopted, the case as well as its scope should be clearly defined (Creswell & Plano Clark, 2017). The case examined in this study is teachers' time management in science classes where they perform scientific inquiry-related in-class activities.

Participants

The study group consists of five science teachers working in a school in Western Anatolia. The participants were selected using the convenience sampling method, one of the purposeful sampling methods. The convenience sampling method can be preferred in cases where it is difficult to select the study group with random or systematic non-random techniques (Fraenkel, Wallen & Hyun, 2012). The convenience sampling method offers significant advantages to researchers in terms of time and implementation (Leedy & Ormrod, 2005). Among the participation criteria were having at least 5 years of professional teaching experience, having taught a science class, and currently instructing a science class. Participation to the study was voluntary. The participant teachers are known to have received training on inquiry-based science education and STEM education.

Data Collection

The data collection of the research was carried out in parallel with the in-service training process. Data were

collected in the form of video recordings. Action cameras were provided to teachers to enable them to film their lectures in high quality. As such, one class video of each teacher was analyzed in terms of use of time. The researchers assumed the role of observers during data collection.

After the data collection stage, each teacher participated in a two-stage in-service mentoring program. In order to examine how teachers used time during their classes before participating in the study, videos were from the first stage of the study were analyzed. The participants filmed their classes both before and after taking place in the mentioned mentorship program. As the aim was to examine the usual flow of the class, the researchers had not interfered with participants' choice of teaching venue. Each participant filmed itself delivering lecture to a classroom to which they have been assigned before. Teachers covered their subjects in classrooms, laboratories, or in another venue they found appropriate. Thus, it was possible to analyze the classes in a holistic manner by taking into account all variables.

The video recordings of the classes were stored by the codes assigned to the participants, in addition to their dates and the stage from which they are. The researchers watched the class video recordings and used the scale they had developed to analyze the change in the time allocated by teachers for the stages of scientific inquiry after the in-service training the latter received.

Data Analysis

The video recordings were analyzed using the scale developed by the researchers. The analysis was made to assess whether teachers sufficiently utilized scientific inquiry in their classes. Accordingly, it was examined whether the three stages of scientific inquiry were completed within the class period. The analysis variables are were time allocated for the stages of scientific inquiry, the percentage weights of the durations of the said stages, and the teacher behaviors and practices that caused loss of time.

The "Time Scale for Scientific Inquiry Classroom" (see Annex) was used by the researcher during the analysis of the video recordings. This scale consists of two dimensions, namely "academic time" and "non-academic time". "Academic time" refers to the periods of time when the teacher or students are actively performing scientific inquiry activities. Academic timeframe AB 7. Academic time, with reference to the booklet of the EU's Fibonacci Project (Borda Carulla, 2012), has been determined to include the stages of ‘building on pupils’ ideas’, ‘supporting pupils’ own investigations’, and ‘supporting analysis and conclusions. Here, whether teachers ask their students questions that encourages the latter to use their previous experiences is associated with building on ideas; the ability of teachers to encourage students to perform scientific inquiry by forming hypotheses, making predictions, testing their predictions, and obtaining data through observation and measurements is associated with supporting pupils’ own investigations; and students communicating the results of their inquiries, making evidence-based inferences, and discussing their findings is associated with supporting analysis and conclusions. Non-academic time, on the other hand, is defined as the periods of time during the course when neither the teacher nor the students are engaged in teaching and learning activities. This period includes portions of the class such as chatter between students, as well as teacher taking attendance and handing out and arranging class materials. The

developed scale was used to examine whether the stages of scientific inquiry were completed during the class, and if yes, how much time was allocated for them and whether the they were carried out sequentially, as well as time losses. Each stage of scientific inquiry was evaluated in terms of duration (in minutes and seconds), the share within the entire duration of the class, and the employed scientific inquiry method.

Validity and Reliability of the Scale

Various methods can be used to ensure internal and external validity in qualitative research. Among these methods are prolonged involvement, member checking, and peer debriefing (Holloway & Wheeler, 1996). In order to ensure the internal validity of this study, field experts were consulted. In order to ensure the validity of the study, the opinions of relevant experts on the prepared scale were consulted. The scale was finalized after four revisions were made in line with the opinions of the consulted experts. In order to ensure external validity of the study, the environment in which the study was carried out and the participant profiles were introduced. The fit index was calculated based on the data obtained from the videos analyzed by the researchers. One of the methods used to determine the agreement between the findings of multiple researchers on a situation is to calculate the agreement between raters (IRR-Inter Rater Reliability). Aiken (2000) defines interrater reliability as the degree of consistency between the scores calculated by two or more researchers in a given measurement. The inter-rater reliability formula proposed by Miles and Huberman (1994) was used to determine the interrater reliability. The IRR value was calculated to be over 82%; an IRR value of 70% and above indicates that the measurement tool is suitable to be used in a study.

Results

The participants of the study teach at the same level of education. The participants' years of professional experience, the level of education at which they teach, and the subject of the class that was video recorded are given in Table 2.

Table 2. Participants' Years of Professional Experience and The Subject of the Video Recorded Class

Teacher	Years of Experience	Level of Teaching	Course Subject
Aslı	14	Kindergarten	Buoyancy
Elif	7	Kindergarten	Buoyancy
Handan	20	Kindergarten	Buoyancy
Oyku	17	Kindergarten	Buoyancy
Ozge	19	Kindergarten	Dissolution

Table 2 shows that all participants have more than 5 years of teaching experience. The subjects of the video-recorded classes were determined to be buoyancy and dissolution. The durations of the class videos analyzed by the researchers are given in Figure 1.

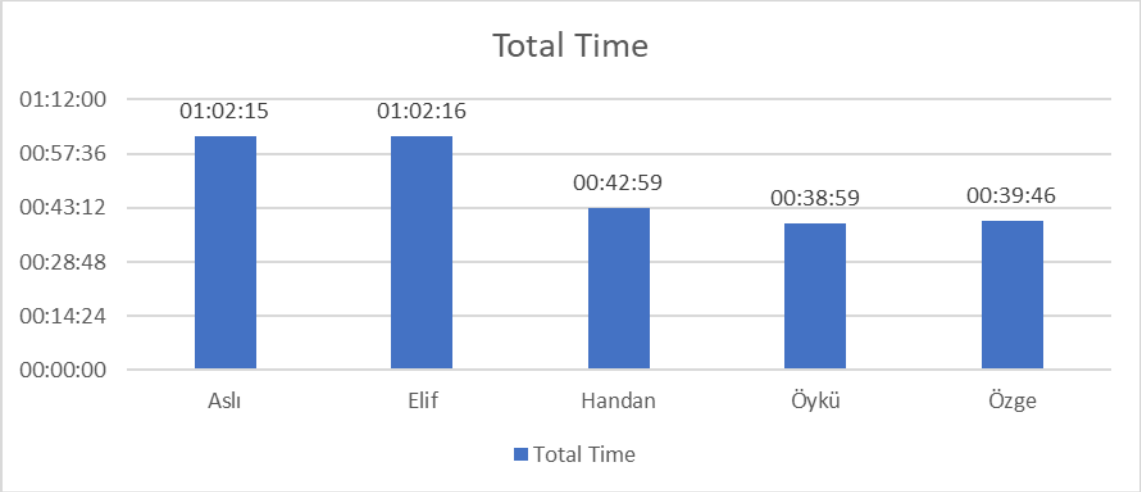

Figure 1. Comparison of the Durations of the Video-Recorded Classes

Figure 1 shows that there is a difference between the time teachers can allocate to scientific inquiry activities. As the course durations of the participants are different, the time allocated for the three stages of scientific inquiry was taken into account in terms of minutes and seconds. For example, if the class duration of a teacher is 1 hour, 2 minutes, and 16 seconds, this duration was taken into consideration as 62 minutes and 16 seconds, and percentages of the time teachers allocated for scientific inquiry activities were calculated accordingly. The comparison of the percentages of the class duration allocated by teachers for the stages of scientific inquiry is given in Figure 2.

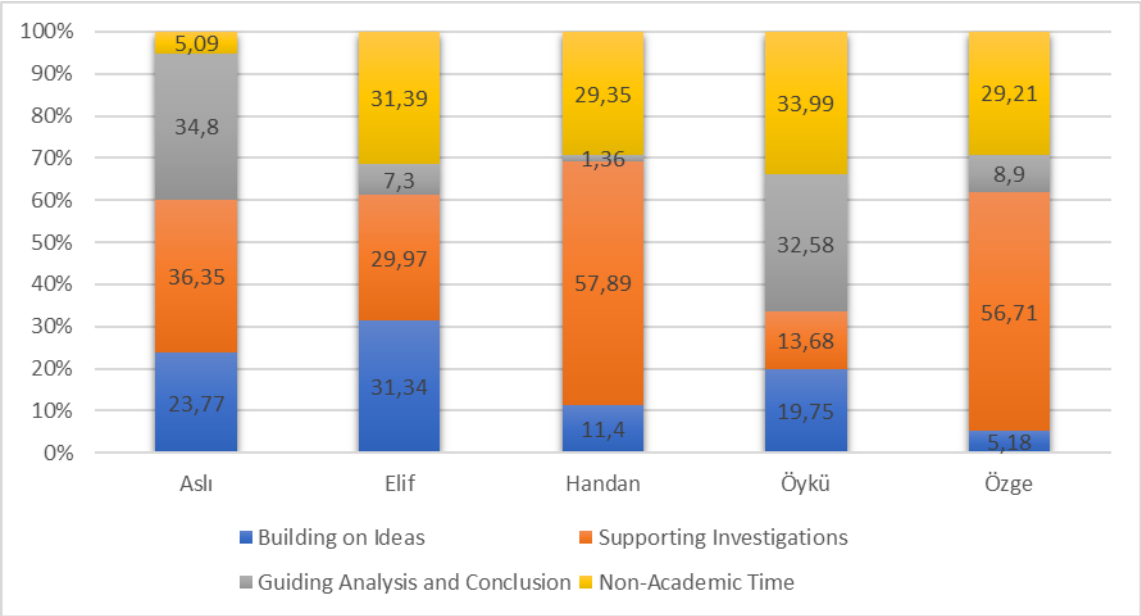

Figure 2. The Percentages of the Class Duration Allocated by Teachers for the Stages of Scientific Inquiry

Figure 2 shows that the participants dedicated differing periods of time to the three stages of scientific inquiry. It can be seen that the time allocated for the 'building on ideas' stage was the longest in Elif's class, in which 62% of the class duration was allocated for this purpose, while Ozge only dedicated 10% of the class duration for it.

The time allocated for supporting pupils' own investigations was the longest in Handan's class, in which 82% of the class duration was allocated for this purpose, while Oyku only dedicated 22% of the class duration for supporting pupils' investigations. Finally, as for the supporting analysis and conclusions, Oyku dedicated the longest time with 37% of the class duration while the shortest time was allocated by Handan with 1%. It can be observed that Handan did not spare enough time for supporting analysis and conclusions.

The teachers are seen to have spared differing periods of time for building on ideas, supporting pupils' investigations, and supporting analysis and conclusions. Generally, as the 'supporting pupils' investigations' stage is the one in which students are the most active both mentally and physically, the longest time should be allocated for this stage. However, allocating more time for this stage than necessary may hinder allocating the required time for other stages. How Handan managed the course can be shown as an example to this case. Handan, who allocated 82% of the course duration for the supporting pupils' investigations, could not spare enough time for the 'supporting analysis and conclusions' stage and completed the course without being able to proceed to it. On the other hand, it is seen that Aslı and Ozge have managed their courses in a more balanced manner, allocating similar portions of the class to different stages. It can be seen that Oyku and Elif did not allocate enough time for the 'supporting pupils' investigations' stage.

According to Figure 2, Aslı allocated 23.77% of the course duration for building on ideas, 34.8% for supporting pupils' investigations, and 36.5% for supporting analysis and conclusions; 5.09% was of the course duration was non-academic time. The column chart demonstrates that Aslı allocated course time evenly among the three stages of scientific inquiry. It was seen that at the 'building on ideas' stage, which covered 23.77% of the course, Aslı asked questions related to daily life that encouraged the students to use their previous experiences. In this stage, almost all students shared their ideas. The 'supporting pupils' investigations stage' was the longest scientific inquiry stage, taking up 36.35% of the course duration. It was seen that at this stage, students designed their own experiments and recorded their observations on the worksheets distributed by the teacher. The use of varied materials by the teacher, Aslı, was seen to expand the scope of observation and enrich the course. It can be argued that the fact that Aslı prepared course material in advance helped to use the course period efficiently. At the 'supporting analysis and conclusions' stage, the students' predictions and observations were compared. Lastly, Aslı utilized the drama method in the evaluation of the course.

According to Figure 2, Elif allocated 31.34% of the course duration for building on ideas, 29.97% for supporting pupils' investigations, and 7.3% for supporting analysis and conclusions. It was seen that in Elif's class, the non-academic time corresponds to 31.39% of the course duration, which was more than any other portion of the class period. Elif asked questions that encouraged the students to use their previous experiences, and almost all students answered these questions. However, it was seen that Elif was significantly late in proceeding to the 'building on ideas' stage. In scientific inquiry applications, sufficient time should be allocated for students to test their predictions and make observations. It was observed that Elif asking disconnected questions during the 'building on ideas' stage occasionally caused the class to derail. This hindered the allocation of sufficient time to the other stages of scientific inquiry.

According to Figure 2, Handan allocated 11.7% of the course duration for building on ideas, 57.89% for supporting pupils' investigations, and 1.36% for supporting analysis and conclusions, in addition to the non-academic time, which corresponds to 29.35% of the class duration. The observer notes show that Handan allocated sufficient time for the 'building on ideas' stage, that students were asked questions that encouraged them to use their previous experiences, and that she attentively listened to the answers of the students. However, this teacher was observed to have lost time while preparing and distributing worksheets to the students at the 'supporting pupils' investigations' stage. The main reason behind this loss of time was that the said materials were not prepared for distribution in advance. Despite this loss of time, Handan was able to allocate enough time for the students to design their experiments and make predictions and observations. However, this hindered the allocation of sufficient time for the 'supporting analysis and conclusions' stage. Handan, therefore, could only spare 35 seconds to the last stage before it was time for a break, which meant that scientific inquiry could not completely performed.

According to Figure 2, Elif allocated 19.75% of the course duration for building on ideas, 13.68% for supporting pupils' investigations, and 32.58% for supporting analysis and conclusions, in addition to the non-academic time, which corresponds to 33.99% of the class duration. The column chart shows that in Oyku 's class, non-academic time was longer than all other stages. Although the teacher sending students to wash their hands as a part of COVID-19 measures and preparing the course material in the meantime can be regarded as a loss of time, the fact that the teacher quickly distributed the course materials to the students in the next stage can be argued to have partially compensated the lost time. Oyku allocated 32.58% of the course duration to the ' supporting analysis and conclusions' stage, where students discussed and compared their predictions and observations. The teacher encouraging the students who made incorrect predictions by saying "all contributions are valuable" was a remarkable and admirable detail.

According to Figure 2, Ozge allocated 5.18% of the course duration for building on ideas, 56.71% for supporting pupils' investigations, and 8.9% for supporting analysis and conclusions, in addition to the non-academic time, which corresponds to 29.21% of the class duration. Ozge was able to complete all stages of scientific inquiry, and the stage to which she allocated the longest time was the 'supporting pupils' investigations', where students carried out experiments and made observations. It was observed that Ozge was not very well at either associating the subject with daily life or encouraging students to compare their predictions and observations at the 'building on ideas' stage.

So, because spending too much time at a given stage of scientific inquiry consequently decreases the time allocated for other stages, the teachers cannot completely cover the subject in the duration of the class. The balance between the times allocated for the three stages of scientific inquiry directly affects the efficiency of the act of inquiry itself. Therefore, time-sensitive course planning is essential for teachers to be able to complete all three stages of scientific inquiry within the course period.

Findings on the Stages of Scientific Inquiry

In the second part of the rubric developed by the researcher, analysis was conducted in order to find out which

stages of scientific inquiry were utilized in the video recorded science lessons. It is known that the teachers received scientific inquiry training before participating in the study. Accordingly, it was observed that this training helped teachers to follow a suitable pattern in encouraging students to perform scientific inquiry. Findings of the analysis regarding the stages of scientific inquiry that teachers utilized in their classes are given in Table 3.

Table 3. Stages of Scientific Inquiry Utilized by Participants in their Video-Recorded Classes

	Building on Ideas	Supporting Investigation	Supporting Analysis and Conclusions
Aslı	✓	✓	✓
Elif	✓	✓	✓
Handan	✓	✓	X
Oyku	✓	✓	✓
Ozge	✓	✓	✓

Table 3 shows that Aslı, Elif, Oyku, and Ozge utilized all three stages of scientific inquiry in their classes. However, as the class period ended before being able to the ' supporting analysis and conclusions' stage, Hande could not utilize all three stages of scientific inquiry. Therefore, this stage was construed as "uncomplete" for Hande's class. So, it has been concluded that teachers usually possess the necessary knowledge on scientific inquiry and its stages; however, they may have time management problems while putting this knowledge to use during classes, which clearly demonstrates the importance of planning in utilizing scientific inquiry.

Findings on the Sequency of the Stages of Scientific Inquiry

Here, findings obtained from the Time Scale for Scientific Inquiry Classroom on the sequency of the stages of scientific inquiry have been presented. In this section, the sequence in which teachers utilized the stages of scientific inquiry, namely building on ideas, supporting investigations, and supporting analysis and conclusions, during class has been analyzed vis-a-vis the course duration expressed in minutes.

The findings of the study show that the periods of time allocated by teachers for the three stages of scientific inquiry, as well as their periods of preparation, preferred method of teaching, and evaluation processes, vary. It was seen that the differences in the times allocated for different stages of scientific inquiry affected the efficiency of these stages. Nevertheless, 4 out of 5 participants were able to complete all stages of scientific inquiry in their classes. No similarities were observed between the times allocated by the participants to the different stages of scientific inquiry. Also, it was observed that the length of the non-academic time within the class period negatively affected the timely completion of the stages of scientific inquiry. Although the training teachers received on utilizing scientific inquiry in their classes seems to have been useful, it was seen that they also need training on time management.

Discussion

In the study, the class videos filmed by the participant teachers were analyzed using the scale developed by the researcher. When literature on scientific inquiry is reviewed, it was observed that the main challenge teachers face

in terms of planning scientific inquiry activities for their classes is the constraint of time (Jones, Gott, & Jarman, 2000; Mumba, Banda & Chabalengula, 2015; Staer et al., 1998). This situation is also valid for classes that are held in laboratories (Booth, 2001). The findings of this study show that teachers are usually able to complete the stages of scientific inquiry in their classes, but they have issues regarding time management. It has been observed that although the participants are known to have received in-service training on the utilization of scientific inquiry in their classes, time allocation is not a part of their class preparation. Consequently, teachers who spend a lot of time at one stage of scientific inquiry need to compensate the loss of time by allocating less time than needed to the other stages. The findings of this study are found to be similar to the findings of the studies in the literature.

It is known that scientific inquiry encourages learning in students with different levels of academic success and from different backgrounds (Cuevas, Lee, Hart, & Deaktor, 2005; Palincsar & Brown, 1992). Scientific inquiry is an efficient way to learn and teach science (Anderson, 2002). There is evidence in the literature that scientific inquiry helps students to understand and interpret science concepts (O'Neill & Polman, 2004). It was seen in the video recordings examined as a part of the study that scientific inquiry encouraged students to actively contribute and express themselves. Another point that is worth mentioning is that scientific inquiry provided ease for the teacher as well. The information and skills gained through scientific inquiry, as well as the excitement of comparing experiments and observations, are factors that ensure knowledge retention in students. In light of the findings of the study on student participation and behaviors, it has been concluded that scientific inquiry is an effective way of science teaching. This conclusion indicates a parallelism between the findings of this study and the relevant studies in the literature.

Conclusion

In addition to the problems they have with the allocation of time, teachers are also found to have difficulties with planning and managing scientific inquiry activities. This is thought to have an impact on teachers' use of time. The sequency of the stages of scientific inquiry affects the time teachers allocate to these stages. It has been seen in this study that pre-class preparation by teachers can prevent the loss of time during the class. It has been revealed that teachers should take measures to minimize non-academic time in order to use the academic time effectively during class. In conclusion, the practice of scientific inquiry in science classes should be carried out in a way to allocate sufficient time to each stage. Although it poses certain difficulties to teachers, it is an undeniable fact that scientific inquiry is an effective approach in science education, because humans, by nature, are more prone to learning through scientific inquiry than any other approach.

Recommendations

Similar studies can be carried out with a focus on different subjects and levels of education. Accordingly, the scale developed by the researcher for this study can be adapted in accordance with the subject and level of education focused on in the study. Thus, the strengths and weaknesses of teachers in terms of efficient use of time can be investigated more comprehensively; professional development programs can be developed accordingly.

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Annex. Time Scale for Scientific Inquiry Classroom

This scale has been developed to monitor the time teachers allocate for the stages of scientific inquiry in their classes. The scale also measures whether the teachers utilize the stages of scientific inquiry sequentially or not.

The Stages to be Followed in Scientific Inquiry Activities

Building on Ideas At this stage, the teacher is expected to propose a theoretical framework and take steps to encourage students come up with ideas about the subject. Accordingly, the teacher needs to elaborate on the relevant basic concepts, provide an interdisciplinary perspective, and associate the subject with daily life while creating the theoretical framework. In the 'building on ideas' stage, the teacher is expected to stimulate students' sense of curiosity, enroucage students to use their existing knowledge and experiences, help students to understand the nature of science, and use supporting materials (board, worksheet, etc.).

Supporting Investigations: At this stage, the teacher is expected to support students in designing their own research. This stage is where the students make predictions, establish hypotheses, and make observations to design experiments of their own. The teacher is expected to assist students in recording the data on the changes they notice in their experiments.

Supporting Analysis and Conclusions: At this stage, the teacher is expected to encourage students to think about the evidence obtained from the experiments. This is the stage where students compare the results of their experiments, discuss their predictions and observations, examine how their ideas changed from before to after the experiment, and try to develop different perspectives. The teacher is expected to guide the students in these processes.

Non-Academic Time: Refers to the period of time when neither the teacher nor the students are engaged in academic activities. The communication between the teacher and the students have been observed to weaken during this period. At this stage, the students are not engaged in class activities; sometimes even turmoil can be observed in non-academic time. Students' discussion within or between groups is not regarded as non-academic time.

IDENTIFYING INFORMATION
Teacher's first and last name:
Video code:
Video analysis date:
School name:
The name of the course:
Subject covered in the course:
Grade:
Number of students:
The observer's first and last name:

Total Time:		Academic Time			Non-Academic Time
Time Interval (min:s-min:s)	Duration (s)	Building on Ideas	Supporting Investigation	Supporting Analysis and Conclusions	
Total					

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School Management and Climate to Enhance Parental Involvement

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Abstract

The aim of this study was to investigate the views of parents and teachers on school principal's role in shaping a school climate that favors parental involvement. The research is based on the theory of bio-ecological systems. Data was collected from 236 parents/guardians and teachers of Primary Education in Western Thessaloniki (North Greece) using a structured questionnaire. The identification of the principal's contribution to the school climate indicated that the general school climate are formed positively at high values in its four dimensions. The role of administration in shaping all dimensions of the school climate is estimated more positively by teachers than the students' parents. The identification of the principal's contribution to parental involvement revealed particularly positive views of teachers and parents on the active involvement of parents in the educational process on all five dimensions. Differentiations of teachers and parents/guardians emerged regarding three dimensions of parental involvement such as school-family communication, parents' volunteering and school cooperation with the wider community. The important finding is the strong positive correlations that emerge between the variables that assess the principal's contribution to climate change and the variables regarding parental involvement.

Introduction

Within the framework of the theory of ecosystems, the family and the school - as they are at the center of these systems- emerge as key interacting forces in the development of the individual (Bronfenbrenner & Ceci, 1994; Penderi & Petrogiannis, 2017). For many researchers (Cohen et al., 2009; Pourrajab et al., 2015; Berkowitz et al., 2017), school's climate, in other words the 'personality' or 'atmosphere' of the school, is the key to its effective and successful interaction with the students' families, while the role of the executives is highlighted by international studies (Griffith, 2001; Lazaridou & Gravani, 2015; Povey et al., 2016) as crucial in establishing a strong and beneficial school-family relationship. Bronfenbrenner's (1979) theory offers, even today, a conceptual framework of the school climate phenomenon as a prerequisite for beneficial school-family interaction, in the sense that the process takes place at the level of the 'intersystem'.

Parental Involvement

The family-school relation is often met in the international literature, not only as 'family-parental involvement' (Hoover-Dempsey et al., 2005; Seginer, 2006) but, also, as 'parental engagement' (Harris & Goodall, 2008;

Hands, 2013), 'parental/guardian participation' (Mahuro & Hungi, 2016) and 'family-school partnership' (Epstein, 1995; Christenson, 2003). Regardless of the verbal description given to it, it is a multidimensional phenomenon (Penderi & Petrogiannis, 2013), which includes the broader behaviour and actions of parents related to school education (McCormick et al., 2013), the common school and family actions/practices aiming to promote the knowledge and the abilities of the students (Hands, 2013) and the views and the expectations of the parents (Seginer, 2006).

For the first time, a clear definition of parental involvement (Patrikakou, 2008; Tran, 2014) is introduced into the educational law of the United States of America (USA), during the educational reform. This legislative text passage defines parental involvement as: "the involvement of parents in frequent, reciprocal and effective communication with the school, which concerns the academic performance of students and participation in various school activities" (No Child Left Behind Act of 2001).

According to Epstein and her colleagues the purpose of the family-school community alliance is to organise activities that activate, engage, guide, and motivate students towards personal improvement and progress (Epstein et al., 2002, p.21). The emphasis placed on capturing the above relationships as 'collaborative', characterizes the contribution the researcher's model - which has ecosystem effects - in the management of family and school cooperation. In addition, she contributed to the formulation of six types of parental involvement in the educational process which are structured as follows: a) parenting, b) communicating, c) volunteering d) learning at home, e) decision making and f) collaborating with community (Epstein, 1995, p.705).

Research directly links parental involvement in Primary Education with better school performance of students in a variety of subjects (Topor et al., 2010) and mostly, mathematics (Mahuro & Hungi, 2016). Parental involvement is indirectly linked to the academic performance of students in primary schools, having a positive influence to the variables regarding their self-esteem (Rogers et al., 2009). Still, at a young age, it has a positive long-term effect on children's school performance in Secondary Education (Barnard, 2004).

The study of the literature also indicates that it contributes positively to the improvement of students' behavior at school. (Harris & Goudall, 2008). Parents' involvement in education contributes to the professional satisfaction of teachers (Aldridge & Fraser, 2015; Sotiriou & Iordanidis, 2015). It has a positive effect on their morale (Eboka, 2017), on their commitment to school goals (Brault et al., 2014), on their sense of self-sufficiency (Petrogiannis & Penderi, 2014) and boosting their confidence in managing family relationships (Thompson et al., 2017). It is also an important means of personal development and self-improvement of parents (Povey et al., 2016).

School Climate

According to the USA National School Climate Council (2007, 5), the school climate:

> "is based on the patterns of experiences that people experience in the school environment and reflects the norms, goals, values, interpersonal relationships, teaching and learning practices , as well as the organizational structure of the school".

Nowadays the above definition is adopted by pioneers in school climate research (Cohen, 2013; Thapa et al., 2013) while most researchers (Cohen et al., 2009; Cohen, 2013; Thapa et al., 2013; Schueler et al., 2014) agree on the following four dimensions: a) physical and emotional safety, b) teaching and learning, c) social relations and d) physical/natural school environment. Other research distinguishes between school climate and school culture (norms, values, beliefs) which in the above definition, are not separated (Geraki, 2013).

The positive climate is strongly related to the school performance of the students (Macneil et al., 2009; Etxeberria et al., 2017) and is indirectly identified as a factor in strengthening students' commitment to school goals (Fatou & Kubiszewski, 2017; Manaf & Omar, 2017). Research links the positive climate, mainly in the areas of school-family communication and safety, with increased levels of parental involvement (Pourrajab et al., 2015).

The literature supports the important contribution of leadership in shaping a positive climate and therefore contribute in the productivity and efficiency of the organization (Macneil et al., 2009; Lezha, 2017). There are many dimensions and types of climate that are evaluated (Geraki, 2013). Greek and Cypriot teachers consider important the contribution of the Principals in shaping a favourable climate for learning and therefore as a factor of effectiveness of the School Management (Athanasoula-Reppa & Lazaridou, 2008; Geraki, 2013). However, the organizational climate of Greek schools in some dimensions is moderate, due to the increased bureaucratic work of principals (Lazaridou & Tsolakidis, 2011).

In Australia, parents describe the principal as the ‘founder’ of human relationships within the school, while focusing on his communication skills and his daily presence on the school premises (Barr & Saltmarsh, 2014), creating the feeling that parents are welcome in the school unit environment. The staff of Greek schools maintain a positive attitude towards parental involvement and express the need for more school-family cooperation, giving parents the opportunity to participate actively in the educational process (Lazaridou & Gravani, 2015). The importance of the climate and the contribution of the school administration mainly in the areas of communication, information, encouraging participation in volunteer activities and active involvement with issues that concern the families of students (Povey et el., 2016), are listed as the most important strategies for enhancing school and family collaboration.

Method

The study aimed to investigate the contribution of the principal in shaping a school climate that enhances parental involvement in Greek school, as there are few studies on the issue. The contemporary Greek educational reality, where parents and teachers often come into conflict, especially in primary education, is highlighted. The principal's contribution in shaping the school climate was assessed in terms of four dimensions of the school climate (Cohen et al., 2009; Cohen, 2013; Thapa et al., 2013; Schueler et al., 2014). Levels of parental involvement were assessed for five of Epstein's six dimensions (1995). The dimension of home learning guidance was excluded, as it was estimated that the respective proposals of the research tool are addressed exclusively to parents and guardians and not to teachers. Figure 1 shows a representation of the model on which the study was based.

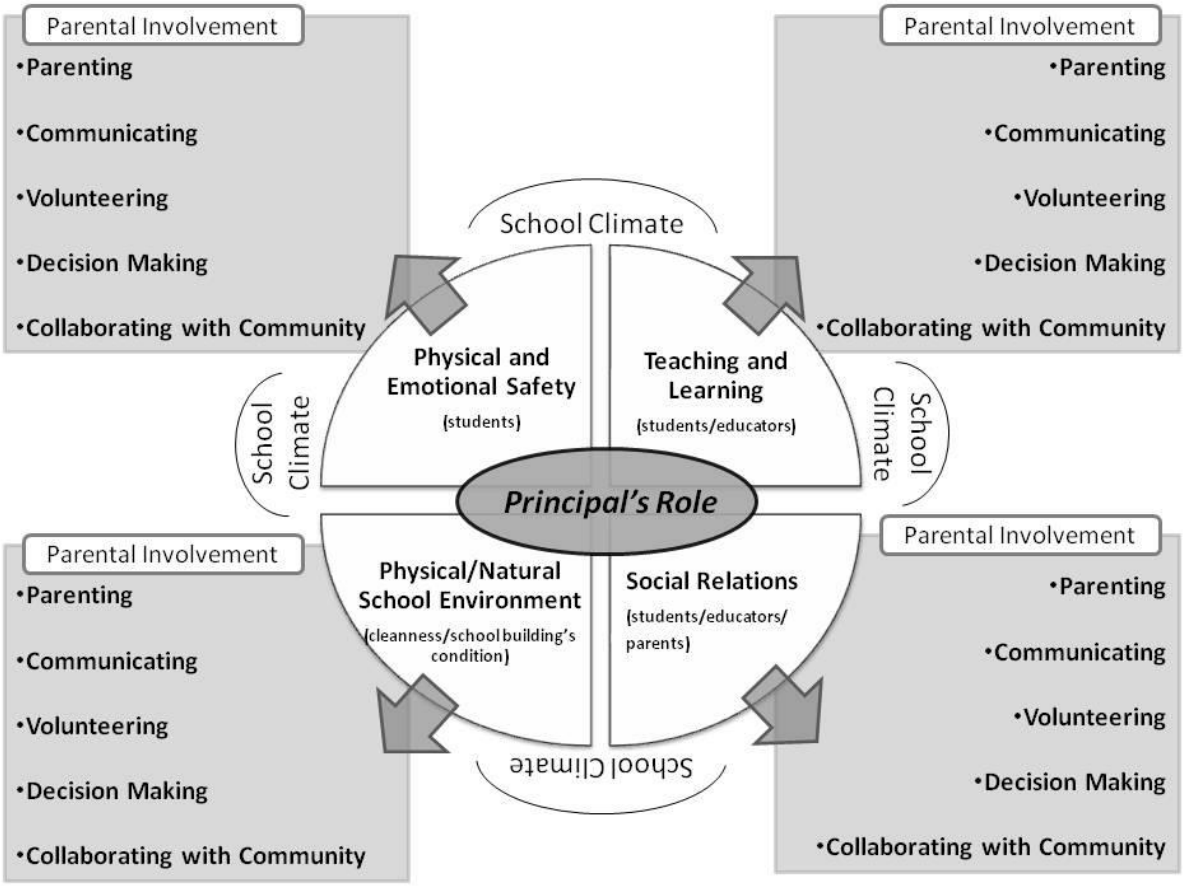

Figure 1. Model of the Study

Drawing upon a sample of 236 parents and teachers of the Primary Education of Western Thessaloniki in Greek, a structured questionnaire was developed to measure the principal's contribution in shaping the school climate and the levels of parental involvement. Mann-Whitney U statistical analyzes were performed to identify statistically significant differences in the views of the two groups, regarding the role played by the school principal in the school climate. Differences in the students' class were tested, as well as differences between the two groups in terms of parental involvement. Finally, through the Pearson correlation coefficient, the correlations concerning the contribution of the educational administration to the shaping of the axes of the school climate, in terms of five dimensions of parental involvement were investigated. Data processing and analysis was undertaken with SPSS (IBM Statistics version 24).

The research sample consisted of 236 participants of which 107 were teachers (45.3%) and 129 were parents/guardians of Primary Education students (54.7%). 300 questionnaires were sent, of which 236 were returned completed. Thus, the response rate was 78.6%. The individual characteristics of the teachers and the parents of the sample are presented in Table 1.

A questionnaire was used as a research tool which had 3 parts and a sum of 55 questions. To achieve content validity (Ouzouni & Nakakis, 2011), 15 teachers were asked for their views on the content and order of the questions, as these were published by Epstein et al. (2002). The tool's reliability was tested using Cronbach's

alpha. Questions that threatened the internal coherence of the subscales were excluded from the statistical analysis.

The first part of the questionnaire includes 7 closed-ended questions related to the demographics of the participants. For the construction of Part B, the relevant literature was studied, as well as questionnaires used in the research on the climate of the Whately Elementary School in Massachusetts, USA (National School Climate Center [NSCC], 2015).

Table 1. Sample's Demographic Characteristics

	Characteristics	N Teachers	%	N Parents/ Guardians	%
Participants	Teachers Parents/Guardians	107	100%	129	100%
Gender	Female	76	71%	104	80.6%
	Male	31	29%	25	19.4%
Age	20-29 years	7	6.5%	1	0.8%
	30-39 years	11	10.3%	38	29.5%
	40-49 years	27	25.2%	79	61.2%
	50-59 years	62	57.9%	10	7.8%
	60-69 years	0	0%	1	0.8%
Marital Status	Single	17	15.9%	6	4.7%
	Married	82	76.6%	116	89.9%
	Divorced	8	7.5%	7	5.4%
Education	Gymnasium graduates	0	0%	4	3.1%
	Lyceum graduates	0	0%	37	28.7%
	Bachelor's degree	82	76.6%	61	47.3%
	Master's degree	23	21.5%	7	5.4%
	PhD degree	2	1.9%	1	0.8%
Primary school classes	First, second, third, grade			53	41.1%
	Fourth, fifth, sixth grade			76	58.9%
Teachers' teaching classes	Lower classes teachers	35	32.7%		
	Higher classes teachers	38	35.5%		
	Teachers of special subjects (foreign languages or music)	26	24.3%		
	Teachers of students with special needs and the all-day school	8	7.5%		
Total		107		129	

Part B was re-created with questions that explore the contribution of the educational administration in shaping the school climate axes. It originally included 26 questions one of which was excluded from the statistical analysis due to Cronbach's low value. Overall, the scale showed Cronbach's internal coherence coefficient a = 0.944 with internal coherence indices of the subscales (see Table 2). The answers were on a five-point Likert scale.

Part C of the research tool initially included 22 questions translated from the questionnaire Measure of School,

Family and Community Partnership of Epstein et al. (2002); it evaluated parental involvement in five of its six dimensions. 3 proposals were excluded from the statistical analysis due to low Cronbach's a value. Overall, the five-axis scale of parental involvement showed a Cronbach's internal coherence factor of a = 0.939 with internal coherence indices of the subscales as shown in Table 2. Responses were on a five-point Likert scale.

Table 2. Questionnaire's Sub-Scales and Internal Consistency Indicators for Sub-Scales

Questionnaire sub-scales	Questions Number	Cronbach's a
General Climate Valuation	5	0.81
School Climate		
Principal's role on emotional safety	6	08.5
Principal's role on teaching/learning	5	0.84
Principal's role on natural environment	1	
Principal's role on social relations	8	0.90
Parental Involvement		
Parenting	4	0.90
School-family communication	5	0.82
Parental volunteering	3	0.84
Parental participation in decision making	4	0.76
School-Community collaboration	3	0.86

Results

The averages of the answers of the teachers (M = 4.27) and the parents (M = 3.88) for the general school climate, showed that the opinions of both groups are formed at satisfactory positive levels. From the Man-Whitney U statistical test, for two independent samples a higher valuation of the general school climate was found to be given by the teachers (M = 4.27) than the parents of Primary School students (M = 3.88), U = 4244, p = 0.001.

The means (M) and standard deviations (SD) of teachers' and parents' responses to the role of the Directorate in shaping the four climate axes, as well as the results of the Mann-Whitney U test are presented in Table 3. The most positive views of teachers, as well as parents emerge regarding the contribution of the Principal in the field of safety and the natural environment. The lower test value for students' parents concerns principal's role in shaping social relations. There were statistically significant differences between the two groups of participants, regarding the role of the Principal in shaping all four axes of the school climate.

Regarding the teachers' classroom, the results of the Mann-Whitney U statistical tests did not show statistically significant differences between the two teacher control groups (one of the 3 lower classes and one of the 3 higher classes' teachers). Regarding the class the students were in, the parents of students of last three classes presented more positive views on the role of the Directorate in the areas of physical/emotional security, teaching/learning and social relations. The lowest values of both groups emerged in the axis of social relations. The results of the Mann-Whitney U statistical tests did not show statistically significant differences between the two control groups.

Table 3. Means -Standard Deviations and Mann-Whitney U test

Principal's role on School Climate							
	Teacher		Parent/Guardian				
	M	*SD*	*M*	*SD*	Mann Whitney	Z	*p*
Principal's role on emotional safety	4.39	0.547	4.09	0.756	5409	-2.874	0.004*
Principal's role on teaching and learning	4.33	0.568	3.98	0.762	5008	-3.645	0.000*
Principal's role on natural environment	4.65	0.600	4.28	0.857	5181	-3.762	0.000*
Principal's role on social relations	4.04	0.619	3.74	0.867	5476	-2.735	0.006*

***** Statistical Significance at the level of $p<0.05$; Source: Koutsouveli

The views of both control groups on parental involvement are high in all five axes of parental involvement evaluated in the research. The means (M) and standard deviations (SD) of teachers' and parents' responses to parental involvement, as well as the results of the Mann-Whitney U test are presented in Table 4.

Table 4. Means - Standard Deviations and Mann-Whitney U test

Principal's role in Parental Involvement							
	Teacher		Parent/Guardian				
	M	*SD*	*M*	*SD*	Mann Whitney	Z	*p*
Parenting	3.51	0.866	3.50	0.955	6774	-0.245	0.806
School-Family communication	4.27	0.669	3.87	0.835	4853	-3.944	0.000*
Parental volunteering	3.36	0.912	3.30	1.083	6822	-0.153	0.878
Parental participation in decision making	3.70	0.709	3.69	0.74	6899	-0.005	0.996
School-Community collaboration	3.90	0.826	3.47	0.94	5006	-3.663	0.000*

*****Statistical Significance at the level of $p<0.05$; Source: Koutsouveli

The highest evaluation for the group of teachers' results is in the school-family communication axis. Then there are the dimensions of the school unit's cooperation with the wider community and the involvement of parents in decision making. The evaluation indicator concerning the support of parental care is lower. The lowest average for the teacher team came from the parent volunteering axis. Respectively, for the group of parents the highest average was also presented in the school-family communication axis. Then there are the axes of parental involvement in decision making and support for parental care. The lowest scores are presented in the dimensions of the school unit's cooperation with the wider community and parent volunteering. There were, as observed,

statistically significant differences between the two groups investigated regarding the dimensions of the school's communication with the students' families and the cooperation of the school unit with the wider school community.

To investigate the correlations of the research variables, the linearity of the relationships was first checked through scatter plots. Only positive linear correlations were found - some weaker ones, however - which allowed us to proceed with the calculation of the degree of correlation of the variables, using the Pearson correlation coefficient. The correlation of the role of the educational administration in shaping the axis of the natural environment with the five axes of parental involvement was checked through the correlation coefficient Spearman's rho, as the axis of the natural environment was a categorical and not a continuous variable. In addition, the Spearman correlation coefficient is widely used in non-parametric distributions.

High correlations were found regarding the role of educational directorate in the axis of teaching/learning with all dimensions of parental involvement. The strongest correlations of the study are found in the relationship between the contribution of school administration in shaping social relationships in the school environment, with the five dimensions of parental involvement. Table 5 presents the results of these correlations

Table 5. Principal's role on School Climate and Parental Involvement

		Parenting	School-Family Communication	Parental Volunteering	Parental Participation in Decision Making	School-Community Collaboration
Principal's role on emotional safety	Pearson Correlation	0.587**	0.589**	0.546**	0.475**	0.598**
Principal's role on teaching/learning	Pearson Correlation	0.659**	0.633**	0.626**	0.517**	0.669**
Principal's role on natural environment	Spearman's rho Correlation coefficient	0.391**	0.439**	0.333**	0.326**	0.464**
Principal's role on social relations	Pearson Correlation	0.751**	0.702**	0.698**	0.524**	0.660**

**. Correlation is significant at the 0.01 level (2-tailed); Source: Koutsouveli

Discussion

Identification of the Principal's Contribution on School Climate

The present empirical study indicated that the views of teachers and parents of students in schools of Western Thessaloniki go hand in hand and are formed positively at high values. This is a particularly encouraging finding as the positive school climate is linked to the effectiveness of the school unit (Murphy, 2013) and to the students'

school performance (MacNeil et al., 2009; Fatou & Kubiszewski, 2017). Other studies link the positive climate with students' commitment to the goals of the school unit and the development of a sense of 'belonging' to the school community (Battistich et al., 2003; Manaf & Omar, 2017). The findings regarding the general school climate of the school units are related to previous findings of Pashiardis (2000) in Cyprus and strengthen the belief that in the school units of the Greek and Cypriot territory, the school climate presents satisfactory positive levels shaping the prospects for the efficient operation of schools.

The teachers and the parents of the students seem satisfied with the actions of the school executives of West Thessaloniki in the development of physical and emotional security, teaching and learning, the natural environment and the social relations of the school ecosystem (community). The conclusion is that in Primary Education, principals have more room to better coordinate areas related to the school climate, while, because of the younger age of students, they are in a more direct contact with both children and teachers and, also, with parents and the wider school unit. On the contrary Lazaridou and Tsolakidis (2011), found moderate level of organizational climate in secondary school teachers.

The more positive views of teachers arise in terms of the contribution of management to the consolidation of physical and emotional security and the development of an attractive physical environment of educational units. Previous findings on the natural environment of schools in Cyprus, by Pashiardis (2000, p.233) -in a sample of teachers and principals of Primary and Secondary Education- but also by Pashiardis (2005, p.11) -in a sample of primary school students- showed dissatisfaction of the researched in terms of building infrastructure, cleanliness, condition and shaping of the natural environment of schools. Also, the cleanliness, maintenance and aesthetics of school buildings are the first axes that research focused on the atmosphere of the school environment (Perry, 1908). It is worth noting the difficulty that is presented on the management of the school's natural environment by the school executives, due to lack of resources, as Greece is going through a prolonged (by the pandemic) period of economic recession. Despite the difficulties, it seems that priority was given by the principals of the surveyed schools to the formation of a better natural environment, in collaboration with the Municipalities of Western Thessaloniki that are responsible for the school buildings.

Parents highly value the contribution of managers as well, in the dimensions of physical/emotional security and the physical environment of schools. Principals' interest in the physical and emotional security of the human resources of educational organizations, in addition to the efficiency of the organizations and the high performance of students (Etxeberria et al., 2017), are also associated with reduced incidents of violence and harassment (Thapa et al., 2013).

Indicators concerning the role of principals in shaping social relationships in the school environment are lower for parents. As research shows the importance of the role of educational administration in cultivating and supporting healthy, positive relationships among all those involved in school life (Griffith, 2001; Barr & Saltmarsh, 2014), it is particularly important to consider at the urging of Lazaridou and Tsolakidis (2011), regarding the need for the training of executives focusing mainly on human relations management and less on bureaucratic procedures. In addition, social relations are not easily manageable in a time of economic (and social/health) crisis, such as the one our country is going through.

Differentiations on School Climate between Teachers and Parents/guardians

The present research shows statistically significant differences in the views of the two groups. Teachers present more positive views on the role of administration in shaping all dimensions of the school climate than the students' parents. We can assume that the teachers of the schools perceive more directly the efforts and actions of the principals, in terms of improving the indicators of the school climate. In addition, they are the first recipients of changes and reforms promoted by the central administration and have an impact on the internal policy of each school unit, experiencing more intensely the interventions of the administration in various aspects of school life. At the same time, the interventions of the parents at the level of Primary Education in Greece are frequent and the principals try to keep a delicate balance among all the stakeholders. The finding indicates the need for more intensive efforts, on the part of the administration and management, in approaching parents, creating a welcoming environment, improving the quality of the relationships with families, effective cooperation, parental involvement in decision-making (Barr & Saltmarsh, 2014; Lazaridou & Gravani, 2015; Povey et al., 2016; Dove et al., 2018), but also the need for parents, especially in Primary school, to intervene discreetly or, at least, mainly in pedagogical matters, which concern, mostly and exclusively, the teachers. At the same time, there is a need for frequent evaluation of school climate indicators - taking into account the views of parents - as a means of feedback on the role of the school executives in improving the school climate (Cohen, 2013; Berkowitz et al., 2017).

Differentiations on the Axes of School Climate between Parents of Students of Lower and Higher School Classes

The results of the present study show that the views of the parents of students of higher classes regarding the role of the principal in the areas of physical/emotional security, teaching and learning and social relations are more positive than the views of parents/guardians of students of lower classes. This may be interpreted as follows: the parents of older students have overcome their first fears about the role of the school in the development of their children and have developed confidence in the abilities of the headteacher in everything related to the respective axes. However, according to Berkowitz et al. (2017) the most positive views on the overall atmosphere of schools are presented by the parents of Preschool students. It is possible that the lack of evaluation of the performance of students in Preschool education in relation to the other school levels affects the formation of quality relationships.

Identification of the Principal's Contribution to Parental Involvement

Differentiations in Parental Involvement between Teachers and Parents / Guardians

Teachers and parents of primary school students in Western Thessaloniki present particularly positive views on the active involvement of parents in the educational process on all five dimensions that were evaluated in the research. This finding is a fundamental issue for educational practice and school improvement.

School-family Communication

Teachers seem to value the school-family communication axis very positively. Similar findings appear in the

study of Koutrouba et al. (2009), which argues that Greek teachers generally have a positive attitude towards parental involvement. However, in terms of the school-family communication axis, there are statistically significant differences between the two groups of respondents, with teachers presenting more positive views than students' parents. It is argued that parents, although maintaining positive attitudes about school-family interaction, find it difficult to be activated in this direction (Antonopoulou et al., 2010). This may be due to many reasons. It could be that interventions may be sought in the work of teachers that are not accepted by them or that their daily work does not allow them to communicate frequently and effectively, although the role of the principal in establishing positive climate is considered important (Griffith, 2001; Patrikakou, 2008).

Parents' Volunteering

The views of both teachers and parents regarding the axis of parental volunteering are lower than in all other indicators. Therefore, in the units of Western Thessaloniki, more opportunities should be created for families to participate in the activities and the daily life of the school and to strengthen parental volunteering as an important dimension of parental involvement (Epstein, 1986; Hoover-Dempsey et al., 2005; Berkowitz et al., 2017). The research of Pnevmatikos et al. (2008) points out that Greek parents often confuse participation in school activities with the concept of volunteering or participation in decision-making, which results in parents volunteering to assist in the schools to be mainly the members of the Association of Parents and Guardians. Epstein (1986) argues that the presence of volunteering parents in schools encourages teachers to seek the cooperation and involvement of even more parents. The personal experience of the researchers shows that a small number of volunteering parents are utilized by the schools in the recent years in the distribution of school meals to students. In general, the culture of volunteering does not characterise the Greek school but also the society and the results of this lack are obvious.

School Cooperation with the Wider Community

Statistically significant differences between the two groups of respondents arise, in addition, in the axis of the school's cooperation with the wider community, as teachers present more positive views. Teachers may consider the contribution of the wider community to their work to be important, as the wider community of the school unit is the 'source' of families and, therefore, of the students attending school (Bartell, 2010). At the same time, it can be assumed that the teachers, in the context of their work, collaborate with the Municipalities, local businesses, management services of local monuments of historical or cultural interest, resulting in a more positive view of the school's cooperation with the local community.

Correlation of School Climate Dimensions and Parental Involvement

The Contribution of School Administration to the Axis of Physical/emotional Safety

The present study shows strong positive correlations between the contribution of the educational administration and management in shaping the dimensions of the climate with the axes of parental involvement. The contribution of the school administration to the axis of physical/emotional security is satisfactorily linked to the support of

parental care, school-family cooperation and communication and parental volunteering. The correlation with the axis of parents' participation in decision- making is lower, while the highest correlation is with the axis of the school's cooperation with the wider community. Similar findings emerge from other studies (Mapp, 2003; Povey et al., 2016), supporting the essential role of school management and administration in creating a safe, healthy, welcoming and supportive environment, in which the mutual respect and beneficial interaction with the children's families and the wider community of the school unit take place. Also, the axis of safety is directly related to parental involvement (Goldkind & Farmer, 2013).

The Contribution of School Administration to the Axis of Teaching and Learning

The contribution of administration to the axis of teaching and learning presents equally satisfactory correlations with all axes of parental involvement. The findings show that the role of the principal in the organization and management of an effective school with appropriate logistical infrastructure, expectations for the progress of children, continuous support of teachers' work, recognition of the contribution of all members of the school community in the implementation vision of the unit, is important and influences the point of view of parents, positively affecting their involvement in the educational process and the cultivation of a climate that favors interaction with students' families. The results are related to the findings of Pourrajab et al. (2015). The importance of the findings may mainly come from the fact that in the Greek educational system principals are not directly involved in the teaching and learning of students, but only creating the conditions for a favorable educational process. At the same time they teach a few hours. The number of teaching hours is determined by the number of students in the school. However, in the present study, when correlating the contribution of the educational administration to the climate with the involvement of parents, the correlations were found to be much stronger. It seems that the efforts of the principals in cultivating a climate that favors the interaction with the students' families, are perceived positively by the teachers and parents who participated in the study and are associated with their active participation in the education of the children.

The Contribution of School Administration to the Axis of Physical/natural Environment

The role of the principal in shaping the physical environment of the school units shows positive correlations, however weaker (than the other dimensions of the climate), with the axes of parental involvement. Therefore, teachers and parents consider the role of the principal more important in shaping other factors and not so much the natural environment in the improvement of which they are not directly involved. In Greece the financing of the schools is done by the School Committees of the Municipalities and concerns all the school units, the principals of which do not have many possibilities to shape the natural environment that they would like and this has started to be more widely understood and accepted. Other research reduces the physical environment of the school unit as an important axis of the school atmosphere, both for teachers (Pashiardis, 2000) and students (Pashiardis, 2005).

The Contribution of School Administration to the Axis of School Cooperation with the Wider Community

Moderate correlations were found in the axis of the school's cooperation with the wider community. The

cooperation of the Directorate with the Municipalities and the School Committee that undertakes the cleaning, maintenance and aesthetics of the school buildings will probably project to the society a better image of the school that may have a positive effect on the attitudes of the wider neighborhood, the families of the new students or visitors. But it does not seem to have a significant effect on school-family collaboration. On the contrary, better preparation is suggested to prospective educators and future principals- leaders to conduct effective family and community involvement programs and practices (Epstein & Sanders, 2006).

Social Relations Development

Particularly important is the fact that the role of the principal in the axis of social relations, as a factor of parental involvement, is recognized by both parents and teachers who participated in the research. The highest correlations arise between the principal's contribution to the dimension of social relations and the axes of parental care support, school-family communication and parent volunteering. Balanced social relationships obviously pave the way for successful school-family communication and further contribute to the parents' intention to attend school as a volunteer or to accept the school unit's efforts to support parental care. The dimension of school-family communication is considered by Greek parents as the strongest axis of their involvement that is found to affect the school performance of children (Pnevmatikos et al., 2008).

Similarly, the findings of previous studies highlight the role of administration and management in successful communication, in creating positive interpersonal relationships and in cultivating trust (Griffith, 2001; Barr & Saltmarsh, 2014; Povey et al., 2016; Lezha, 2017). At the same time, its coordinating role is emphasized, in 'learning' to cooperate all participants in the learning process (Cohen et al., 2009). In conclusion, the fact that the overall results of the study concern Western Thessaloniki, an area with a lower standard of living compared to other areas of Thessaloniki, proves to be very important and promising.

Conclusion

It is positive that the research found satisfactory levels of school climate in the Primary schools of Western Thessaloniki, despite the existence of statistically significant differences between teachers and parents. Thus, the principal emerges as the main shaper of the conditions and atmosphere of the educational organization, in order to have a systematic collaboration of the school with the families of the students. In addition, the study shows statistically significant differences between teachers and parents/guardians regarding the levels of parental involvement.

The need to train teachers and prospective principals on the subject must be emphasized (Epstein & Sanders, 2006; Patrikakou, 2008; MacNeil et al., 2009; Cohen et al., 2009; Berkowitz et al., 2017). Cultivating and maintaining a good school climate must be a priority for all. The principal is responsible together with the teachers to establish a personal form of communication with the parents, to encourage and motivate them, to participate actively in the school. Epstein's exhortation is clear: "The way schools care about children is reflected in the way schools care about the children's families" (1995, 701).

Notes

1. The use of the words management, administration, executives as well as principal, director, headteacher are used alternatively in the text as in the Greek language there are no differences between the concepts.
2. It is noted that the term parent/parental includes that of a guardian as well.

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Pseudo-Scientific Beliefs and Knowledge of The Nature of Science in Pre-Service Teachers

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Abstract

This study aimed to determine the levels of pre-service teachers' nature of science (NOS) knowledge, assess their pseudo-scientific beliefs, and examine the relationship between aspects of their NOS knowledge and these beliefs. It also aimed to determine whether NOS knowledge and pseudo-scientific beliefs depended on the discipline and gender. A survey method was conducted in this study. Data were collected from 215 pre-service teachers who are being educated in different fields in a state university. Two different five-point Likert scales were applied. Scale 1, which has three factors, measured pseudo-scientific beliefs, while Scale 2, which has seven factors, measured NOS knowledge. As a result, pre-service teachers' NOS knowledge was found to be inadequate and their pseudo-scientific beliefs were excessive. All factors of Scale 1 were positively correlated with each other, and they were correlated with some components of NOS knowledge. Significant differences were found between disciplines in the analysis of the factors of Scale 2; however, no significant differences were found between genders.

Introduction

The nature of science (NOS) is an important component of scientific literacy (Michaels, Shouse, & Schweingruber, 2008; Williams & Rudge, 2019). NOS has thus been a dominant topic within science education (Allchin, 2011; Erduran & Dagher, 2014; Irzik & Nola, 2011). Norris and Phillips (2003) refer to NOS as one of the eleven features that define scientific literacy and claim that it is necessary to "distinguish between what is and what is not science". The NOS is a way of understanding science that includes features such as the experimental nature of scientific knowledge, observation, inference, creativity and imagination, scientific theories and laws, theory-dependency, and sociocultural values (Turgut, 2009). Understanding the NOS gives students the ability to correctly understand and interpret the scientific knowledge that they will be exposed to throughout their lives, and allows them to apply appropriate scientific research principles at all levels and for all purposes. (Lederman & Lederman 2014). If this does not occur, pseudo-science may replace science.

Pseudo-science refers to arguments and theories that are not supported by empirical evidence and violate the known laws of science, but which use scientific language to appear valid science (Shermer, 2002). The importance of raising awareness about the negativity of pseudo-scientific beliefs and the positive effect of the NOS is obvious

when making important or life-changing decisions. However, research has shown that the information found in books and the media often contains many misconceptions about the NOS (e.g. Abd-El-Khalick, Waters & Le, 2008; Altındağ, Tunç Şahin & Saka, 2012; Irez, 2008). The media may frequently be responsible for the spread of misconceptions and non-scientific knowledge (Castelão-Lawless, 2002; Shein, Li & Huang, 2014). According to a survey conducted by the PEW Research Center, 42% of American adult people believe spiritual energy can be located in physical objects, 33% believe in reincarnation and 29% believe in astrology (Gecewicz, 2018). Studies have shown that pseudo-scientific ideas, such as beliefs in the existence of aliens, sixth sense, telekinesis, astrology, lucky numbers, ghosts, and telepathy are relatively common (National Science Board, 2006). In the literature, studies examining the relationship between pseudo-science and the NOS have generally used pseudo-science to determine the levels of understanding of the NOS (e.g. Kirman-Çetinkaya & Laçin-Şimşek, 2012; Saka & Sürmeli, 2017; Turgut, Akçay & Irez, 2010; Yardımcı, 2019). These data show that a significant section of society has difficulty distinguishing between scientific and non-scientific thinking. Castelão-Lawless (2002) claims that the critical skills that can distinguish between science and pseudo-science are not taught to individuals in schools.

It has been suggested that teachers may responsible for the inadequacy of the general public's knowledge of the NOS (Aslan, Yalçın & Tasar, 2009; Lederman, 2007). Teachers with naïve opinions about the NOS and how to distinguish between science and pseudo-science will not be able to guide their students properly (Ağlarcı & Kabapınar, 2016). Schwartz et al. (2007, p.23) emphasize that teachers should be aware of the NOS as a part of the science literacy and science program, as well as being aware that students need to be motivated to learn science. Individuals' perceptions of science and scientists are shaped at a young age, and this greatly affects whether they continue to study science in the future and whether they are able to solve the problems they encounter in their daily lives by using the scientific thinking skills (Angın & Özenoğlu, 2019). Teachers believe that it is necessary for students to understand the NOS, but this is generally insufficient (Abd-El-Khalick, 2005). They should also have pedagogical knowledge about how to teach the NOS (Hanuscin, Akerson & Phillipson-Mower, 2006) and be willing to teach it.

The NOS as a topic has been increasingly brought into education in recent years, and both students and teachers have engaged more successfully with it; however, resistance has continued to be met from both groups (Lederman, Bartos, & Lederman, 2014). For example, science teachers usually do not want to spend time teaching the NOS (Williams & Rudge, 2019). Many science teachers think that education about the NOS takes away valuable time from teaching the traditional science content (Clough, 2006). Researchers have queried whether teachers can adequately answer the question "What is science?" and whether the current curriculum and teaching materials support their efforts to teach their students about the NOS (Emran, Spektor-levy, Tal, & Assaraf, 2020).

Teachers, pre-service teachers, students, and academics have similar misconceptions regarding the NOS (Abd El-Khalick, et. al., 2008; Altındağ, et. al., 2012; Irez, 2006). According to research, teachers' knowledge of the NOS is generally inadequate (e.g. Aslan, et. al., 2009; Akerson, Abd-El-Khalick & Lederman, 2000; Erdoğan, 2004; Doğan Bora, 2005). It has also been determined that pre-service teachers believe a number of common myths about the NOS (Doğan Bora, 2005; Köseoğlu, Tümay, Üstün, 2010). Having pseudo-scientific beliefs may be the

result of not having enough knowledge about the NOS. On the other hand, these beliefs themselves may hinder the acquisition of knowledge of the NOS, because this knowledge should enable individuals to understand the difference between science and pseudo-science. It should thus be investigated whether there is a relationship between the two domains and whether they are affected by each other.

Despite studies showing that teachers' and pre-service teachers' misconceptions about the NOS are similar, no study has been found on whether the misconceptions about the basic components of the NOS differ. Snow and Collini (2012) argued that modern education systems divide society into the "two cultures" (the natural sciences and the social sciences) and it is important whether there is a difference between these two cultures' views of the NOS. There is a limited number of studies on whether teachers' and pre-service teachers' inadequate knowledge of the NOS differs with regard to the subjects they teach (Gül, 2016; Kızılcık, Temiz, Tan, & Kandil-İngeç, 2007). Because NOS is often associated with science lessons, studies on the NOS and pseudo-science have mostly been conducted with science teachers or pre-service science teachers (e.g. Ağlarcı & Kabapınar, 2016; Arı, 2010; Aslan, 2009; Mesci, 2016; Saraç & Cappellaro, 2015). It should be considered, however, that students interact with elementary school teachers before science teachers (Saraç & Cappellaro, 2015). However, the number of studies on the NOS related to elementary school teachers is limited (e.g. Arı, 2010; Saraç & Cappellaro, 2015; Tatar, Karakuyu, & Tüysüz 2011; Yalçın & Yalçın, 2011). In addition, some studies of pre-service preschool teachers have shown that they had an insufficient understanding of the NOS (e.g. Erdaş Kartal & Ada, 2018; Türk, Yıldırım, Bolat, Ocak İskeleli, 2018; Uçar & Şahin, 2018). Pre-service preschool teachers and elementary school teachers have similar misconceptions to pre-service science teachers with regard to the NOS (Erdaş Kartal & Ada, 2018; Saraç & Cappellaro, 2015). Moreover, there is only a limited number of studies on the NOS knowledge of pre-service art, music, history and social science teachers (e. g. Gürel, 2002, Tufan, 2007; Kızılcık, et. al., 2007).

Although research has shown that teachers' and pre-service teachers' misconceptions about the NOS are similar, some studies have also found that gender plays a role in the types and level of pseudo-scientific beliefs (e.g. Gürgil, 2019; Preece & Baxter, 2000; Sjödin, 2002; Williams, Francis, & Robbins, 2007). Could this be due to those of different genders having different knowledge of the NOS? The question can be asked whether teachers' knowledge of the basic components of the NOS differs gender. According to some curriculum documents and literature (American Association for the Advancement of Science, 2007; National Research Council, 2012; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003), one of the aspects of the NOS is knowing that both women and men are involved in, and contribute to, science.

NOS educators should adopt an attitude that strongly supports the idea that there are no gender differences when studying science (Chen, et. al. 2013). Gender stereotypes are often built on the belief that men have higher levels of cognitive ability (superior intelligence, the capacity for genius etc.) than women (Emran, et. al., 2020). It is important to understand whether teachers are affected by these prejudices. NOS knowledge should not differ according to the gender of the teacher. Some studies have found a significant difference in teachers' and pre-service teachers' NOS knowledge in terms of gender (e.g. Beşli, 2008; Doğan Bora, 2005; Gül, 2016; Gürgil, 2019; Preece & Baxter, 2000; Saraç & Cappellaro, 2015; Sjödin, 2002; Williams, et. al., 2007), while others have not (e.g. Kirman-Çetinkaya & Laçin-Şimşek, 2012; Şenler & İrven, 2016; Yenice, Özden & Hiğde, 2017).

Teachers provide society with knowledge about the NOS. It is therefore important to first determine the structure and level of pre-service teachers' NOS knowledge. It should also be determined which variables may affect the level of knowledge of the NOS components, and the possible relationship of these variables with pseudo-scientific beliefs. No study has been found in the literature investigating the relationship between the components of the NOS. Teachers should have a scientific point of view in order to provide their students with a scientific perspective. A teacher who aims to give students the ability to distinguish between what is scientific and what is not, should first be able to make this distinction for themselves. It is thus important to examine the relationship between the two domains. This may allow NOS educators to update their own training according to these differences. For this reason, the research questions of this study were as follows:

- What is pre-service teachers' level of NOS knowledge?
- What is pre-service teachers' level of pseudo-scientific beliefs?
- Is there any relationship between the components of NOS knowledge and pseudo-scientific beliefs?
- Is there any significant difference between the level of pre-service teachers' NOS knowledge and pseudo-scientific beliefs in terms of their discipline?
- Is there any significant difference between the level of pre-service teachers' NOS knowledge and pseudo-scientific beliefs in terms of gender?

The hypotheses of this study were determined as follows:

- Hyp1: Pre-service teachers' level of NOS knowledge is sufficient and they have a low level of pseudo-scientific beliefs.
- Hyp2: There is no relationship between the components of NOS knowledge and pseudo-scientific beliefs.
- Hyp3: There is no significant difference between the level of pre-service teachers' NOS knowledge and pseudo-scientific beliefs in terms of the discipline.
- Hyp4: There is no significant difference between the level of pre-service teachers' NOS knowledge and pseudo-scientific beliefs in terms of gender.

To sum up, this study aimed to determine the levels of pre-service teachers' NOS knowledge, pseudo-scientific beliefs, and the relationship between the components of NOS knowledge and pseudo-scientific beliefs. It also aimed to determine whether NOS knowledge and pseudo-scientific beliefs depended on the variables of discipline and gender.

Theoretical Framework

What is the NOS?

Like the concepts and theories, it involves, science itself also evolves continuously (Abd-El Khalick & Lederman, 2000). NOS has been defined differently over a long period of time by various philosophical, sociological, and historical thinkers (Abd-El-Khalick & Lederman, 2000). However, Emran, et al. (2020) state that most researchers agree that the NOS relates to scientific knowledge that is empirical, tentative, theory-laden, creative, inferential, socially constructed, and structured in propositions or sets of propositions, such as scientific laws and theories, which are distinct from each other (e.g. Abd-El-Khalick 2012; Erduran & Dagher, 2014; Lederman & Lederman,

2014). Science teachers, scientists, historians, philosophers, and science sociologists have reached a similar consensus on the aspects of the NOS (Osborne, et. al., 2003). This conceptualization has been called the "general aspects" conceptualization or the "consensus view" of the NOS (Kampourakis, 2016).

The NOS includes both the nature of scientific knowledge and the nature of scientific research (Emran, et. al., 2020). On the basis of international curriculum documents and the literature (American Association for the Advancement of Science, 2007; National Research Council, 2012; Osborne, et. al. 2003), the following aspects of scientific information are included in the conceptualization of the NOS (Emran, et. al., 2020): (a) scientific claims are reasoned and empirically-based; (b) most experiments or observations can be repeated by researchers in a variety of settings; (c) scientific knowledge is durable but uncertain. It can be changed significantly in the light of new findings or perspectives; (d) new methods and technological innovations contribute to change; (e) science is made by people who are constrained by their society and culture; (f) both women and men are involved in science and contribute to science.

According to the consensus view, there are seven to 10 NOS components that can be taught in the school context and be used to determine students' misconceptions about the NOS. Even among advocates of the consensus view, however, the terminology employed can change. For instance, they are divided as to whether NOS is domain-general or domain-specific (Kampourakis, 2016). Some researchers claim that the NOS is domain-general, so all sciences share some common features and common epistemological claims can be made for all sciences (Abd-El-Khalick, 2012; Irzik & Nola, 2011; Kampourakis, 2016; Lederman & Lederman, 2014; Niaz, 2010; Osborn et al., 2003). Others claim that NOS is domain-specific, so every scientific discipline has its own unique methodological, ontological, and epistemological features (Schizas, Psillos, & Stamou, 2016).

Some researchers have criticized the consensus view and suggested alternatives. There have also been advocates for the view that NOS should be taught by asking questions that go deeper into the nature of scientific studies, rather than focusing on specific components or principles (Clough, 2011). This approach focuses on what the NOS is as well as how it should be taught. Matthews (2012) proposed using the term "features of science" (FOS) instead of NOS, based on the idea that it was "more philosophically and historically refined and developed to benefit teachers and students". In addition, several researchers have argued for the use of the history of science (HOS) to teach the NOS (McComas, 2010; Rudge, Cassidy, Fulford, & Howe, 2014). The HOS provides an extremely contextual approach to NOS teaching, which can introduce human agency to the topic. However, empirical studies on the use of the HOS to teach the NOS are inconsistent (Williams & Rudge, 2019).

Irzik and Nola (2011) suggested the "Family Resemblance Approach", suggesting that the conceptualization of the general aspects of the NOS neglected the differences between scientific disciplines due to its weakness. This approach is based on the understanding that some members of a family are more similar to each other than others. They demonstrated that although scientific disciplines have some common aspects, this is not sufficient to define science. They proposed four specific categories: (a) research processes, (b) goals and values, (c) methods and methodological rules, and (d) products. These categories were expanded by Dagher and Erduran (2016). However, this approach is more difficult to apply in a school context than the consensus view is (Cofré et al., 2019).

There is still a lot to be done to define the best model for teaching the NOS (Lederman & Lederman 2014). For example, it is not yet known why some aspects or features of the NOS are more difficult to understand than others (Mesci & Schwartz, 2017); whether some aspects of the NOS lead to the implicit learning of other aspects (Seung, Bryan & Butler, 2009), or whether there is a real relationship between students' understanding of the NOS and scientific concepts (Lederman, 2007). In this study, the consensus view of the NOS was taken into consideration. The scale used as a data collection tool in the study, was developed according to the improved form of the general aspects approach (Özcan & Turgut, 2014).

Everyone should have a basic knowledge of science-related concepts and the NOS. However, the NOS is associated more with those who study the natural sciences than those who study the social sciences and arts. The education that these two groups received causes their worldviews to be completely different (Snow & Collini, 2012). This difference also affects their perspective on the NOS. For example, Arı (2010) concluded that pre-service science teachers have more accurate knowledge of scientific theories and laws than pre-service elementary school teachers. Some pre-service social sciences teachers stated that scientific methods could be used to explain supernatural events, on the other hand, some stated that supernatural events were not within the limits of science (Gürgil, 2019).

Gender is another variable where knowledge about the NOS may differ due to social stereotypes. Some studies state that males have more knowledge of the NOS than females (Yenice et al., 2017). Nevertheless, teachers should adopt a position that strongly supports the idea that there are no gender differences while studying or working in scientific disciplines (Chen et al., 2013). Gender stereotypes suggest that males are more intelligent and more scientifically inclined and that females have a lower chance of success in science (Fredricks, Hofkens, Wang, Mortenson, & Scott, 2018). As a result of these ideas, teachers may encourage boys more than girls and have lower expectations of girls (Makarova & Herzog, 2015). When girls believe this stereotype, it may adversely affect their performance. For this reason, it is important that teachers are not affected by these stereotypes.

Relationship between NOS aspects

There has not been enough scientific research in the literature regarding the relationship between the aspects of the NOS. There are various findings regarding these aspects. It is known that individuals find it hard to properly grasp concepts related to science, including observation, inference, laws and theories. For example, a significant number of people think that there is a hierarchical relationship between theories and laws (Abd-El-Khalick, 2005). This relationship, from the most unreliable to the most reliable, is as follows: hypotheses, theories, and laws (Abd-El-Khalick, 2005; Akerson, et al., 2006). Theories and laws are different components of scientific knowledge. Theories explain why and how an event happened in that specific way; however, laws describe how it happened at all. The idea that there is a hierarchical relationship between theories and laws is very resistant to change (Küçük, 2008). In this regard, improving some components of NOS knowledge is more difficult than others (Mesci & Schwartz, 2017). In particular, these views regarding theories and laws are harder to change (Akerson, et. al., 2000; Köseoğlu, et al., 2010). For example, in one study, the majority of pre-service preschool teachers accepted that scientific theories were subject to change, but claimed that scientific laws were correct and

immutable (Erdaş Kartal & Ada, 2018).

There are other misconceptions about the NOS, especially with regard to scientific concepts. According to Cofré et. al. (2019), the most common misconceptions are: "(1) hypotheses become theories and theories become laws; (2) science is an objective enterprise, and scientists do not use their experience and background to analyze results or propose explanations; (3) scientific knowledge is an immutable truth; and (4) only one scientific method exists." Some aspects of NOS are still debated by scientists. According to Uyar (2016), even philosophers of science agree that there is no universal criterion for determining the limits of science yet. It can thus be understood why people also have difficulties determining the limits of science.

In recent years, some approaches to NOS teaching have emerged through experimental studies (e.g. Abd-El-Khalick & Lederman 2000; Lederman 2007). However, to what extent these misconceptions have an effect on people's understanding of the NOS, and the relationships between them, have not yet been clearly revealed.

What is Pseudo-Science?

With the positivist approach that started with Comte in the 19th century, studies on the HOS also began. The main purpose of the study of the HOS was not to produce a narrative of the development of science, but to examine the philosophical and epistemological problems of science and to reveal its nature in this way (Topdemir & Unat, 2019). Two of the most important questions in science are "What is the scope of science?" and "What are the limits of scientific problems?". While doing science, the following should be decided: (i) how to answer questions (what method does science use?), and (ii) how to place limits on the scientific and the non-scientific (what are the limitations of science?).

The responses of the logical positivism of the Vienna Circle to the question of what cannot be scientific led to a discussion of what "seems scientific but not" with the development of Popper's principle of falsifiability in the late 1920s (Uyar, 2016). The problem of discriminating science from pseudo-science is called "Popper's discriminatory problem" (or the "boundary problem in science"). Many criteria, such as objectivity, verifiability, testability (or confirmability), changeability, replicability, cumulativeness, progressiveness, factuality, and predictability have been proposed as the criteria for discrimination in the discussions focusing on the characteristics of science (Bunge, 2011; Cortinas-Rovira, Alonso-Marcos, Pont-Sorribes, & Escriba-Sales, 2015). Some thinkers have focused directly on the characteristics of pseudo-science, such as isolation – which means that it occurs far from mainstream science and is rarely part of in academic activities –, abuse of empirical data, lack of self-correction mechanisms, not being open to new hypotheses and methods, and reliance on beliefs rather than data (Bunge, 2011).

Although most scientists are aware of the nature and limitations of science, it may be more difficult for students who do not fully grasp the NOS to distinguish discourses disguised as scientific discourses from true knowledge. For many students, science has such great authority that their attitude toward ideas claiming to be "scientific" can be quite uncritical (Keranto, 2001). According to the results of a survey conducted at Hollins College, Virginia,

37% of students believed in ghosts, 64% in telepathy, and 46% believed that plants would grow faster if people talked to them (Woods, 1984). Another survey conducted at Concordia College in Montreal, Canada found that 85% of students believed in extrasensory perception (ESP), 55% in astrology, 49% in psychic healing, and 43% in ghosts (Gray, 1984). Such beliefs are still common in the general population even today (Silva & Woody, 2022). The media supports these beliefs and contributes to their dissemination.

Some studies have concluded that pseudo-scientific beliefs are mostly seen in females, especially with regard to paranormal beliefs (Gürgil, 2019; Preece & Baxter, 2000; Sjödin, 2002; Williams, et al., 2007). Preece and Baxter (2000) also state that females are less skeptical about pseudo-scientific beliefs. However, this may relate to the type of pseudo-scientific beliefs. For example, males tend to believe in pseudo-scientific claims like the existence of UFOs, and aliens, although females believe more in pseudo-scientific claims such as fortune-telling and horoscopes.

NOS and Pseudo-Science

Pseudo-science can be defined as all claims that lack scientific evidence and credibility, although these are often said to be scientific (Shermer, 2002). In other words, even if practitioners of pseudo-science state that their methods and knowledge they have is scientific, these claims are often not in conformity with scientific standards and do not have the chance to be verified both experimentally and theoretically (Pavić, 2013; Preece & Baxter, 2000). When a claim about the universe arises whose accuracy cannot be tested within a scientific framework, it is clearly a pseudo-scientific claim.

When scientists evaluate whether there is a cause-and-effect relationship between two events, they try to correlate them by creating a sample. For pseudo-scientists, it is enough to show that they have some similarities with each other to establish or imply some relationship between the two events. This characteristic feature of pseudo-scientific knowledge makes it difficult for the general public to distinguish between science and pseudo-science (Tseng, Tsai, Hsieh, Hung, & Huang, 2014).

Believers in pseudo-science do not have a particular personality trait. It is possible that these individuals believers do not have any specifically distinct characteristics, such as a “will to believe”, that are different from those of non-believers (Lindeman, 1998). According to Lindeman (1998), individuals believe in pseudo-scientific ideas because they meet many basic social needs and make it easier to explain and make sense of unexpected events encountered in everyday life. Many pseudo-sciences offer a vision of a world that is more coherent, controllable, and acceptable (Lindeman, 1998).

It is known that the existence of pseudo-scientific beliefs makes it difficult to grasp the NOS (Qtait, Abu Liel, Massad, & Asfour, 2021). Instead, exercises to distinguish between pseudo-science and science improve individuals’ epistemological perspectives and facilitate understanding of the NOS (Ayvacı & Bağ, 2016). Good (2012) claims that studying NOS will not help students understand what pseudo-science is. He emphasizes that students should learn clearly through the examples so that they can recognize pseudo-science when they see it.

Method

This study used the survey method to determine pre-service teachers' pseudo-scientific beliefs and their NOS knowledge. The essence of the survey method can be explained as "questioning individuals on a topic or topics and then describing their responses" (Jackson, 2011). To test the hypotheses, the data collected from pre-service teachers with the Likert scales were first analyzed by descriptive methods, and then the inferential statistics method was used.

Study Group

Data were collected from 215 pre-service teachers who were attending a state university in Ankara, Turkey. The sample was selected randomly from among sophomore students in the Faculty of Education. Data were collected in a manner that respected ethical practices and research on human subjects. The aim of the research was clearly stated to the subjects and the research group was chosen from those pre-service teachers who volunteered. In addition, no personal information (even their names) other than the gender and department of the pre-service teachers was requested. Thus, the identities of the subjects participating in the research were kept confidential. The participants were studying different disciplines, namely, physics teaching (N=28), science teaching (N=5), mathematics teaching (N=67), social sciences teaching (N=66), elementary school teaching (N=1), preschool teaching (N=8), foreign languages teaching (N=26), geography teaching (N=1), music teaching (N=3), art teaching (N=2), and psychological counseling and guidance (N=8). They were therefore classified into two groups: Natural Sciences and Mathematics Teaching (NSMT), which contained physics teaching, science teaching, and mathematics teaching; and Social Sciences and Art Teaching (SSAT) which contained the remainder. The demographics of the sample are given in Table 1.

Table1. Demographics of Sample

Field / Gender	Female		Male		Total	
	N	%	N	%	N	%
NSMT	82	82.00	18	18.00	100	46.51
SSAT	90	78.26	25	21.74	115	53.49
Total	172	80.00	43	20.00	215	100.00

As shown in Table 1, most of the pre-service teachers were female (80%) and the rest were male. 46.51% of the pre-service teachers were studying NSMT and 53.49% were studying SSAT. The data were collected from the sample in February 2020, before pandemic restrictions began.

Data Collection Tools and Analysis of data

To achieve the purpose of the study, two different Likert scales were applied to the sample. The first scale, which will be called Scale 1 throughout the study, was the Pseudo-Scientific Beliefs Scale (PSBS). This was developed by Çetinkaya and Taşar (2018). The scale has 21 items, and the Cronbach's alpha coefficient was found to be

.849. This scale was applied to determine the level of the pre-service teachers' pseudo-scientific beliefs.

The second scale was applied to obtain the views of pre-service teachers about the NOS. This scale, which will be called Scale 2 throughout the study, was the Nature of Science Beliefs Scale (NOSBS). Scale 2 was developed by Özcan and Turgut (2014). It consists of 37 items and the Cronbach's alpha coefficient was found to be .632. Although .70 and above is widely accepted as the value of a reliability coefficient in science education studies, many studies also consider lower values acceptable (Taber, 2017). Hair, Black, Babin, Anderson and Tatham (2013) noted that a value of .70 is generally agreed upon as an acceptable value; however, they consider that values as low as .60 may be acceptable for exploratory research. Nehring et al. (2015) stated that a test about chemistry knowledge with an alpha value of .55, and which they used in their study, could be considered reliable because "conceptual knowledge may constitute a noncoherent latent construct across a multitude of students". Berger and Hänze (2015) found the alpha coefficient value of the knowledge test they used in their study on the jigsaw learning method to be .45 for the pre-test and .60 or the post-test. They attributed this situation to the broad range of knowledge measurements tested with a limited number of test items. That is, the internal consistency/item equivalence was not expected to be high since the different physics concepts were tested within one instrument. If a scale is multifactorial, a relatively low alpha value does not mean that the scale is not reliable. The items of both scales are presented in the Appendix.

In addition, both scales had been previously validated by their developers in terms of content and construction. To provide construct validity of scales, the Kaiser-Mayer-Olkin (KMO) and Bartlett Test of Sphericity was performed. The KMO values were found to be .81 (Scale 1) and .74 (Scale 2). Similarly, the Chi-Square values (Scale 1: x^2 = 2089.19, Sd = 561, p <.00; Scale 2: x^2 = 4091.37, Sd = 666, p <.00) obtained as a result of the Bartlett test, which was used to examine whether the data was normally distributed in multivariate analysis, was found to be significant. All the factors of both scales are given in Table 2.

As shown in Table 2, Scale 1 consists of three factors, and Scale 2 consists of seven factors. The data were assessed with the help of computer software. Both scales are Likert-type scales: The respondents express their level of agreement to items containing true or false information by choosing options 1-5. In the evaluation, items that represent false (unscientific) responses are reverse-coded. That is, among the Likert items, those which gave correct information were scored from 5 to 1, while those which gave false information were scored from 1 to 5. For all items, 1 point represents an agreement with false information and 5 points represents an agreement with true information. While interpreting descriptive statistics, responses were grouped by levels.

The evaluation criteria were determined by considering the structure of the scales (Kızılcık, et. al., 2007). All the scales are five-point Likert scales. Accordingly, the responses are handled in five levels. The level is whatever range corresponds to the mean of responses to the entire scale or each factor of the scale. A respondent can respond 1 to 5 on each item. That is, no respondent can choose less than 1 or more than 5 points. The average must be between 1-5. The range of 1 to 5 is 4. If we want to divide this range into five equal levels, we have to move to the next level every time we add 4/5 = 0.8. Since a respondent can choose at least 1 point, the starting number of the first level has to be 1.00. For example, if the range 1.00-1.79 is the first level, the range 1.80-2.56 should be

the second level.

Table 2. Factors of Scales

Scales	Factors	Number of Items	Items
Scale 1: PSBS	S1-F1: Pseudo-Physical Claims	9	2, 3, 8, 9, 11, 12, 13, 16, 18
	S1-F2: Pseudo-Predictive Claims	6	4, 5, 6, 7, 15, 17
	S1-F3: Pseudo-Medical Claims	6	1, 10, 14, 19, 20, 21
	Total	21	
Scale 2: NOSBS	S2-F1: Changes in Scientific Knowledge	6	1, 8, 15, 20, 23, 30
	S2-F2: Discrimination Between Observation and Inference	4	2, 13, 21, 25
	S2-F3: Scientific Method(s)	4	3, 19, 29, 32
	S2-F4: Creativity and Imagination	5	4, 9, 17, 24, 37
	S2-F5: Socio-Cultural Impact	8	5, 7, 16, 22, 26, 28, 34, 36
	S2-F6: Scientific Laws and Theories	4	6, 12, 18, 33
	S2-F7: The Postulates and Limits of Science	6	10, 11, 14, 27, 31, 35
	Total	37	

The range of each level is called the evaluation range. The ranges determined for the levels are obtained by adding the evaluation range to the Likert points. The ranges that correspond to each level are called level ranges. The evaluation range was calculated according to the following formula, and the assessment criteria according to the evaluation range are presented in Table 3 and pictured in Figure 1.

Evaluation Range = (Score Range) / (Number of Categories) = (5-1) / 5 = 4 / 5 = 0.8

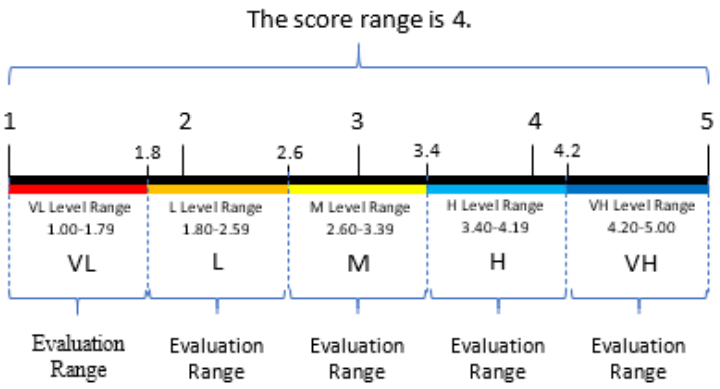


Figure 1. Visualization of Assessment Criteria

As seen in Table 3, 2.59 and below are considered low and very low, while 3.40 and above are considered as high and very high levels. Between 2.60 and 3.39 is considered a moderate level.

Table 3. Assessment Criteria

Level Range	Level
1.00 - 1.79	Very Low (VL)
1.80 - 2.59	Low (L)
2.60 - 3.39	Moderate (M)
3.40 - 4.19	High (H)
4.20 - 5.00	Very High (VH)

In addition to descriptive statistics, some hypotheses were tested using inferential statistics. The Pearson correlation coefficient was used to determine whether there was a significant relationship between the responses to the factors of the scales. In addition, differences between the sample groups and whether the differences were significant were examined with the help of two-way MANOVA.

Results

First, descriptive analysis was performed to determine the levels of pre-service teachers' NOS knowledge and pseudo-scientific beliefs and to thus test Hyp1. Descriptive statistics such as sample size (N), mean, standard deviation, variance, median, kurtosis, and skewness of the data obtained from scales and their factors were determined. Responses were also categorized based on mean according to assessment criteria (see Table 4).

Table 4. Descriptive Statistics of Scales

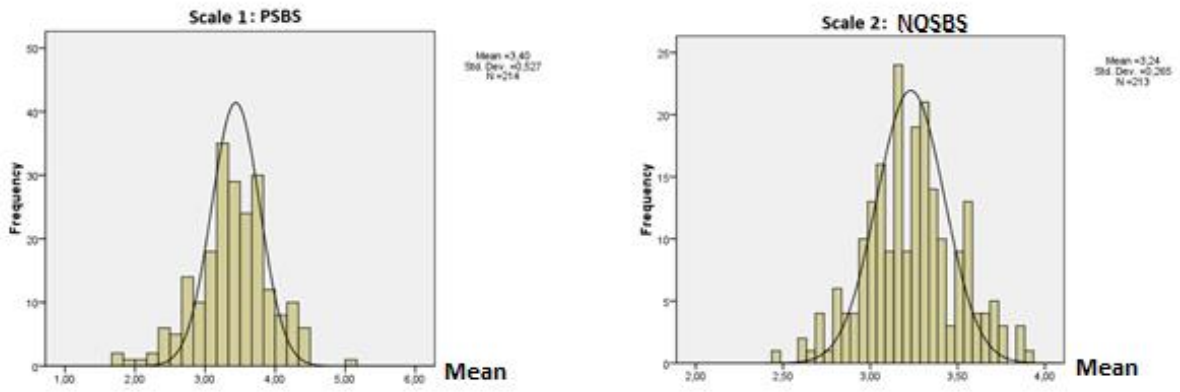
Scale	Factor	N. of Items	N	Mean	Level	Median	Std. Dev	Var.	Skewness		Kurtosis	
									Stat.	Std. Er.	Stat.	Std. Er.
Scale 1: PSBS	S1-F1	9	214	3.627	H	3.67	.568	.323	-.482	.166	.617	.331
	S1-F2	6	214	3.237	M	3.33	.635	.403	-.172	.166	.228	.331
	S1-F3	6	214	3.230	M	3.33	.593	.352	-.333	.166	.681	.331
	Total	21	214	3.402	H	3.43	.527	.277	-.309	.166	.642	.331
Scale 2: NOSBS	S2-F1	6	213	3.725	H	3.83	.532	.283	-.118	.167	.301	.332
	S2-F2	4	213	3.268	M	3.25	.491	.241	.439	.167	.764	.332
	S2-F3	4	213	2.955	M	3.00	.486	.237	-.249	.167	1.149	.332
	S2-F4	5	213	3.193	M	3.20	.638	.407	-.242	.167	-.067	.332
	S2-F5	8	213	3.484	H	3.50	.403	.163	.092	.167	1.025	.332
	S2-F6	4	213	2.754	M	2.75	.771	.595	-.288	.167	-.343	.332
	S2-F7	6	213	2.944	M	2.83	.356	.126	.237	.167	.208	.332
	Total	37	213	3.237	M	3.24	.265	.070	.032	.167	-.025	.332

As seen in Table 4, Scale 1 had a higher mean than Scale 2 in total. Scale 1 was at a high level and Scale 2 was at a moderate level overall. In terms of factors, it can be seen that S2-F6 (Scientific Laws and Theories) had the lowest, and S2-F1 (Changes in Scientific Knowledge) had the highest mean. In total, seven of 10 factors were at the moderate level and 3 (S1-F1, S2-F1, S2-F5) were at the high level. The only high-level factors were Changes

in Scientific Knowledge, Pseudo-physical Claims, and Socio-cultural Impact, with their respective scores in that order.

The responses to Scale 1 showed that the pre-service teachers had a high-level awareness of Pseudo-physical Claims, but they had a moderate-level awareness of Pseudo-predictive Claims and Pseudo-medical Claims. The responses to Scale 2 showed that pre-service teachers had high-level awareness of the Changes in Scientific Knowledge and Socio-cultural Impact components of the NOS, but they had moderate-level awareness of the other components. Their knowledge may thus not have been sufficient, as most of the factors were at a moderate level. It was expected that pre-service teachers would be at a higher level than common people who will go on to undertake the task of educating individuals using a scientific approach. Therefore, Hyp1 is rejected.

The kurtosis and skewness values of the scales and their factors can give us information about whether the data have a normal distribution. According to George and Mallery (2010), "A kurtosis value between ±1.0 is considered excellent for most psychometric purposes, but a value between ±2.0 is in many cases also acceptable, depending on the particular application." Also, Hair, et. al. (2013) say: "Skewness Measure of the symmetry of distribution; in most instances, the comparison is made to a normal distribution … Skewness values falling outside the range of -1 to +1 indicate a substantially skewed distribution." Accordingly, the data show a normal distribution. The mean and median values are close to each other and they support normal distribution. Figure 2 shows the distribution curves of Scale 1 and Scale 2.



(a) (b)

Figure 2. Distribution Curves of Scale 1 (a) and Scale 2 (b)

Inferential analysis to test the hypotheses was performed by parametric statistical methods due to the normal distribution of the data. First, whether there is a relationship between scales and their factors was examined with the help of the Pearson Correlation Coefficient to test Hyp2. Table 5 shows the correlation findings between the factors. In Table 5, r is the correlation coefficient and P is the significance value. Values found significant in Table 5 are written in bold ($P<0.5$). According to Table 5, there were strong, significant, and positive relationships between all the factors of Scale 1. Its factors include the types of pseudo-scientific beliefs. All factors of Scale 1 were positively correlated with each other.

Table 5. Correlations between All Factors of Scales (p<0.5)

Scales	Factors		Scale 1: PSBS				Scale 2: NSBS							
			S1-F1	S1-F2	S1-F3	Total	S2-F1	S2-F2	S2-F3	S2-F4	S2-F5	S2-F6	S2-F7	Total
Scale 1: PSBS	S1-F1	r	1											
		P	*											
	S1-F2	r	**.731**	1										
		P	**.000**	*										
	S1-F3	r	**.695**	**.565**	1									
		P	**.000**	**.000**	*									
	Total	r	**.937**	**.864**	**.837**	1								
		P	**.000**	**.000**	**.000**	*								
Scale 2: NOSBS	S2-F1	r	**.154**	-.015	.101	.097	1							
		P	**.025**	.830	.142	.157	*							
	S2-F2	r	.023	-.043	-.008	-.007	**.236**	1						
		P	.743	.536	.911	.919	**.001**	*						
	S2-F3	r	.084	-.045	-.001	.023	**.225**	.101	1					
		P	.224	.510	.987	.743	**.001**	.141	*					
	S2-F4	r	-.052	-.108	**-.140**	-.107	**.168**	.059	**.210**	1				
		P	.449	.116	**.041**	.119	**.014**	.391	**.002**	*				
	S2-F5	r	**.202**	.033	.100	**.136**	**.349**	**.228**	.120	.128	1			
		P	**.003**	.632	.144	**.047**	**.000**	**.001**	.081	.062	*			
	S2-F6	r	**-.174**	**-.152**	**-.161**	**-.186**	.006	-.060	.111	**.486**	-.083	1		
		P	**.011**	**.026**	**.019**	**.007**	.928	.386	.106	**.000**	.230	*		
	S2-F7	r	-.059	.008	-.074	-.050	.060	.030	-.031	**.245**	.058	**.165**	1	
		P	.389	.902	.284	.471	.387	.658	.652	**.000**	.403	**.016**	*	
	Total	r	.054	-.090	-.046	-.023	**.600**	**.380**	**.425**	**.682**	**.543**	**.496**	**.393**	1
		P	.437	.189	.500	.742	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	*

S1-F3 (Pseudo-medical Claims) and S2-F4 (Creativity and Imagination) were related negatively and significantly. Those who had more pseudo-medical beliefs thought that there was less creativity and imagination in science. S1-F1 (Pseudo-physical Claims) was related positively and significantly to S2-F1 (Changes in Scientific Knowledge) and S2-F5 (Socio-cultural Impact). When respondents had fewer pseudo-physical beliefs, their ability to comprehend the changeability of scientific knowledge and the relationship of science with socio-cultural effects was higher. So, Hyp2 was rejected.

S2-F1 (Changes in Scientific Knowledge) was positively and significantly related to S2-F2 (Discrimination between Observation and Inference), S2-F3 (Scientific Method(s)), S2-F4 (Creativity and Imagination), S2-F5 (Socio-cultural Impact). Pre-service teachers who were aware of the changeability of scientific knowledge were also more aware of the scientific methods, the role of socio-cultural influences, creativity, and imagination in science.

S2-F2 (Discrimination between Observation and Inference) and S2-F5 (Socio-cultural Impact) were significantly and positively related. It can be said that being aware of the role of sociocultural effects in science is about being aware of the distinction between observation and inference.

S2-F4 (Creativity and Imagination) was significantly and positively related to S2-F6 (Scientific Laws and Theories) and S2-F7 (The Postulates and Limits of Science). A significant and positive relationship was also found between S2-F3 (Scientific Method(s)) and S2-F4 (Creativity and Imagination), and between S2-F6 (Scientific Laws and Theories) and S2-F7 (The Postulates and Limits of Science).

The next phase of the study examined whether there was a statistically significant difference between demographic groups. The mean scores of the groups were first determined and can be seen in Table 6.

Table 6. Group Means

Scale	Factors	NST		SSAT		Total		Total	
		Female	Male	Female	Male	Female	Male	NST	SSAT
Scale 1: PSBS	S1-F1	3.65	3.42	3.60	3.77	3.63	3.60	3.65	3.60
	S1-F2	3.23	3.10	3.24	3.34	3.24	3.22	3.23	3.24
	S1-F3	3.18	3.27	3.24	3.35	3.21	3.31	3.18	3.23
	Total	3.40	3.29	3.40	3.53	3.40	3.41	3.40	3.39
Scale 2: NOSBS	S2-F1	3.82	3.73	3.65	3.66	3.74	3.70	3.82	3.65
	S2-F2	3.38	3.26	3.19	3.17	3.29	3.22	3.38	3.19
	S2-F3	2.93	2.84	2.98	3.04	2.95	2.94	2.93	2.98
	S2-F4	3.43	3.05	3.02	3.14	3.22	3.10	3.43	3.02
	S2-F5	3.56	3.29	3.45	3.47	3.51	3.38	3.56	3.45
	S2-F6	2.90	2.87	2.56	2.89	2.73	2.88	2.90	2.56
	S2-F7	3.01	3.01	2.85	3.00	2.93	3.01	3.01	2.85
	Total	3.40	3.29	3.40	3.53	3.24	3.21	3.34	3.15

As can be seen in Table 6, there are mostly no clear differences between the means of the groups. However, whether the existing differences are significant or not had to be examined to test Hyp3 and Hyp4. A two-way multivariate ANOVA (MANOVA) was conducted with gender and discipline as independent variables, and with scores for the scales and scores for the factors as dependent variables. MANOVA, unlike ANOVA, does not increase Type I error. Before the two-way MANOVA is conducted, Box's Test of Equality of Covariance Matrices and Levene's Test of Equality of Error Variances are examined. This is because, to use MANOVA, the following assumption must be met: "The population covariance matrices of each group are equal (this is an extension of homogeneity of variances required for univariate ANOVA)" (Tabachnick & Fidell, 2013). According to the result of Box's Test of Equality of Covariance Matrices, the null hypothesis was that the observed covariance matrices of the dependent variables were equal across groups (Box's M=68.615; F=1.190; P>.05). The findings for Levene's Test of Equality of Error Variances can be seen in Table 7.

Table 7. Levene's Test of Equality of Error Variances for all scales (p<.05).

Scales	Factors	F	df-1	df-2	Sig. (p)
Scale 1: PSBS	S1-F1	2.191	1	211	.140
	S1-F2	.476	1	211	.491
	S1-F3	3.021	1	211	.084
	Total	.014	1	211	.907
Scale 2: NOSBS	S2-F1	4.742	1	211	.031
	S2-F2	2.789	1	211	.096
	S2-F3	2.105	1	211	.148
	S2-F4	.351	1	211	.554
	S2-F5	.070	1	211	.792
	S2-F6	.092	1	211	.762
	S2-F7	2.191	1	211	.140
	Total	.476	1	211	.491

As shown in Table 7, there was no significant value for all factors of all scales, except S2-F1. This result showed that the data were mostly suitable for two-way MANOVA. Gender was considered covariance. The results of the two-way MANOVA can be seen in Table 8.

Table 8. MANOVA Results by Gender, Field, and Field*Gender (p<.05)

Effect	Pillai's Trace	F	Hypothesis df	Error df	Sig. (p)	Partial Eta Squared (η^2)
Field	.111	1.301	10.000	200.000	.008	.111
Gender	.057	.842	10.000	200.000	.292	.057
Field * Gender	.074	1.169	10.000	200.000	.107	.074

There was a significant multivariate effect for the discipline, while there were no significant effects for gender and discipline*gender as shown in Table 8. The results of the analysis show that there was no significant difference between genders in terms of any factor of the scale. In the descriptive statistics for gender, females had a higher mean in Pseudo-physical Claims and Pseudo-predictive Claims and males had a higher mean in Pseudo-medical Claims. But those differences were not significant. The means of the females were higher than males in all the NOS components except Scientific Laws and Theories and The Postulates and Limits of Science in this study. But these differences were also not significant. Hyp4 was confirmed.

For each multivariate procedure, the initial test statistic (given under “Pillai's Trace”) was transformed into a test statistic (given under "F"), which can be compared with an F-distribution with "Hypothesis df" and "Error df" to derive the p-value of the test (given under "Sig. (P)") in Table 8 (Landau & Everitt, 2004). Pillai's Trace was chosen because it is not much affected by small biases in assumptions. This is because there was a small deviation for S2-F1 in Levene's Test of Equality of Error Variances. Partial eta squared shows what percentage of the difference was due to the groups. According to Richardson (2011), the partial eta squared value can be

benchmarked against Cohen's criteria of small, medium, and large effects. He defined effect sizes as small when they are <.2. The effect size was small. Regarding pseudo-scientific beliefs and NOS knowledge, there was no significant difference between male or female pre-service teachers. When there is a significant difference in MANOVA results, this indicates that the independent variable has a significant difference from at least one of the dependent variables. But it does not indicate for which dependent variable there is a significant difference. The test performed to determine which dependent variable(s) has/have a significant difference(s) is called the post hoc test (Field, 2013). The post-hoc test was performed.

Table 9. Post-hoc Test Results by Field (p<.05)

Dep. Var.	Field	Mean	Std. Error	95% Confidence Interval		Type III Sum of Squares	df	Mean Square	F	Sig. (p)	Partial Eta Squared (η^2)
				L. Bound	U. Bound						
S1-F1	NTS	3.607	0.057	3.494	3.72	1.021	1	1.021	3.159	0.077	0.015
	SSAT	3.635	0.053	3.53	3.74						
S1-F2	NTS	3.207	0.064	3.08	3.333	0.263	1	0.263	0.645	0.423	0.003
	SSAT	3.261	0.06	3.143	3.379						
S1-F3	NTS	3.198	0.06	3.079	3.316	0.009	1	0.009	0.026	0.871	0.000
	SSAT	3.257	0.056	3.147	3.368						
S2-F1	NTS	3.805	0.053	3.7	3.91	0.369	1	0.369	1.318	0.252	0.006
	SSAT	3.654	0.05	3.557	3.752						
S2-F2	NTS	3.360	0.049	3.263	3.456	0.462	1	0.462	1.966	0.162	0.009
	SSAT	3.186	0.045	3.096	3.276						
S2-F3	NTS	2.911	0.049	2.814	3.008	0.05	1	0.05	0.209	0.648	0.001
	SSAT	2.990	0.046	2.9	3.08						
S2-F4	NTS	3.354	0.062	3.233	3.476	4.446	1	4.446	11.832	0.001	0.054
	SSAT	3.041	0.057	2.928	3.154						
S2-F5	NTS	3.509	0.04	3.43	3.588	0.822	1	0.822	5.169	0.024	0.024
	SSAT	3.457	0.037	3.383	3.53						
S2-F6	NTS	2.893	0.076	2.742	3.044	2.568	1	2.568	4.463	0.036	0.021
	SSAT	2.624	0.071	2.484	2.765						
S2-F7	NTS	3.011	0.035	2.942	3.081	0.484	1	0.484	3.963	0.048	0.019
	SSAT	2.881	0.033	2.817	2.946						

Values between the mean and the 95% confidence interval on the left side of the Table 9 are the statistics for normal distribution. Type III Sum of Squares explains how much total variation, and df indicates degrees of freedom. As shown in Table 9, significant differences were found for S2-F4 (Creativity and Imagination), S2-F5 (Socio-cultural Impact), S2-F6 (Scientific Laws and Theories), and S2-F7 (The Postulates and Limits of Science) (P<.05). For all factors with significant differences, the differences were in favor of NSMT. Hyp3 was rejected.

Discussion

Levels of Pseudo-Scientific Beliefs and NOS Knowledge

The descriptive analysis results showed that the pre-service teachers' pseudo-scientific beliefs were generally at the moderate level but they had a higher mean score in Pseudo-physical Claims than other pseudo-scientific

claims. Believing a pseudo-medical claim is riskier than believing a pseudo-physical claim because of the risk of damaging one's health. With regard to pseudo-medical claims, such as those made for weight-loss pills, most pre-service teachers should use scientific criteria in their decisions (Saka & Sürmeli, 2017). This idea supports the relationship between using scientific criteria and making the right decision (Greaves- Fernandez, 2010). Individual should want to learn more before believing a claim that will directly affect their health. However, the result of this present study shows the opposite. The pseudo-scientific claims most believed by the pre-service teachers were pseudo-medical ones. Perhaps this should not be surprising, as medicine was the field about which they had the least knowledge. They may also have been influenced by the use of folk remedies, as these are quite common in their socio-cultural environment. Many of the pre-service teachers in the study came from rural areas in which folk remedies are still used today. They are often more easily available and cheaper than going to a health institution. In addition, if they seem to have worked in the past, even to a small extent, then this strengthens people's faith in them. However, most of the time they do not actually work, but only seem to. Moreover, medicine is a highly complicated and specialized field, with complex, hard-to-learn medical knowledge. Even acquiring literacy in the health sciences requires learning a lot of information. Folk remedies, which are often handed down through word-of-mouth and used on a trial-and-error basis, are comparatively simple. It is thus not surprising that the participants in this study would be willing to use them.

Pseudo-predictive beliefs often relate to supernatural entities, such as ghosts and spirits, as well as alien visitations. These topics are very common in the media and are the subject of many science fiction movies. The pre-service teachers may have been influenced by the media and thus have had lower awareness than expected. On the other hand, pseudo-physical claims are related to more widely known laws of physics. These types of claims have a relationship with familiar topics such as astrology or mind-reading. For example, although many believe in astrology, the idea that astrology is not scientific is often emphasized by scientific circles. The war waged by science educators and narrators against prominent pseudo-scientific fields such as astrology may have had an effect on the results.

Studies on the distinction between science and pseudo-science show that people sometimes have difficulties discriminating between science and pseudo-science (e.g. Afonso & Gilbert, 2010; Çetinkaya, Turgut, Duru & Ercan, 2015; Turgut, 2009). Teachers are no exception. Teachers and pre-service teachers in different fields, including physics, chemistry, biology, languages, the social sciences and mathematics, as well as at different levels, such as preschool or elementary school teaching, often remain undecided about pseudo-science and pseudo-scientific beliefs, and may have difficulties distinguishing between what is scientific and pseudo-scientific (Ağlarcı & Kabapınar, 2016; Gül, 2016; Gürgil, 2019; Kirman-Çetinkaya & Laçin-Şimşek, 2012; Şenler & İrven, 2016; Turgut, 2009; Uçar & Şahin, 2018). Pre-service teachers should have sufficient knowledge about how to discriminate between science and pseudo-science before they enter the profession (Turgut, 2007).

Gürgil (2019) determined that pre-service social sciences teachers had insufficient and contradictory thoughts regarding science and pseudo-science. Pre-service teachers can also be affected by non-scientific knowledge in their daily lives (Saka & Sürmeli, 2017). Most pre-service teachers consider astrology to be a science (Şenler & İrven, 2016). In parallel, the majority of high school students have pseudo-scientific ideas, such as a belief in

mind-reading, telepathy and the notion that the lunar cycle can affect people's behavior (Lundström & Jakobsson, 2009). However, as the level of education increases, belief in the presence of paranormal events does decrease (Silva & Woody, 2022). Nevertheless, pre-service teachers may still have pseudo-scientific ideas such as beliefs in luck, horoscopes, and dream interpretation, even when their knowledge of scientific method and knowledge about how to discriminate between science and pseudo-science is quite high (Şenler & İrven, 2016). On the other hand, studies have stated that individuals who grasp the NOS can more easily distinguish what is scientific and what is not (Kirman-Çetinkaya, Laçin-Şimşek, & Çalışkan, 2013).

In this study, the pre-service teachers had a relatively high level of knowledge about the Changes in Scientific Knowledge and Socio-Cultural Impact components of the NOS. According to some studies, the most commonly adopted component of the NOS is the changeability of scientific knowledge (Aslan, 2009; Beşli, 2008; Doğan-Bora, 2005; Morrison, Raab & Ingram, 2009; Özcan, 2011; Saraç & Cappellaro, 2015; Türk, et al., 2018). The vast majority of science teachers think that scientific knowledge may change in the future (Aslan, et al., 2009). Scientific knowledge is reliable and long-lasting. However, this does not mean that it is completely correct or precise. It can change over time, either through evolution or in a revolutionary way (Güneş, 2003). On the other hand, some studies have determined that pre-service teachers do not know enough about the changeability of scientific knowledge (Demir & Akarsu, 2013). Among the NOS knowledge levels, S2-F6 (Scientific Laws and Theories) had the lowest mean, and S2-F1 (Changes in Scientific Knowledge) had the highest mean. The relationship between the two may be related to the misuse of the word "theory" in everyday life. In daily life, "theory" is generally used to mean "assumption". In this sense, it is closer to the concept of "hypothesis". However, this meaning is far from how the word is used when discussing scientific theory. Since hypotheses can be easily dispensed with after testing, they support the concept of the changeability of scientific knowledge. In addition, the idea that socio-cultural influences and scientists' subjectivity affect scientific knowledge also supports the idea that scientific knowledge can change, because subjective knowledge changes more easily than objective. If belief in these two factors ("Changes in Scientific Knowledge" and "Socio-Cultural Impact") is high, it may indicate that there is a relationship between these two components.

Most teachers think that there is a hierarchical relationship between theories and laws (Abd-El-Khalick, 2005; Akerson, et al., 2006; Hanuscin, et al., 2006; Leblebicioğlu, Metin, & Yardımcı, 2012; Saraç & Cappellaro, 2015). This hierarchical relationship, from the most unreliable to the most reliable, is structured as follows: hypothesis, theories, and laws (Abd-El-Khalick, 2005; Akerson, et al., 2006; Hanuscin, et al., 2006; Leblebicioğlu, et al., 2012; Saraç & Cappellaro, 2015; Yalvaç & Craword, 2002). This idea is considered a misconception in the literature (Erdaş Kartal & Ada, 2018). Theories and laws are different components of scientific knowledge. Theories explain why and how an event happened in that specific way; however, laws describe how it actually happened. The idea that there is a hierarchical relationship between theories and laws is quite resistant to change (Küçük, 2008). Improvement in some components of the NOS is more difficult than others (Mesci & Schwartz, 2017). Compared to other components, views regarding theories and laws are more difficult to change (Akerson, et. al., 2000; Köseoğlu, et. al., 2010). For example, in one study, the majority of pre-service preschool teachers accepted that scientific theories were changeable, but claimed that scientific laws were correct and immutable (Erdaş Kartal & Ada, 2018). As discussed above, in daily life the word "theory" is mostly used when talking about

speculative claims or a different point of view. “Theory” in this sense may thus be associated with imprecise claims. Everyday language can cause doubts about the reliability of scientific knowledge and lead to misconceptions. Such misconceptions are called “language-based misconceptions” (Kızılcık, 2021).

The factors S2-F6 (Scientific Laws and Theories), S2-F7 (The Postulates and Limits of Science), S2-F3 (Scientific Method (s)), and S2-F2 (Discrimination Between Observation and Inference) were at a moderate level. All of these factors are related to how science is done and the concepts of science. The pre-service teachers’ knowledge in these areas was insufficient. Even in high school textbooks, the scientific method is usually depicted as a series of steps (Irez, 2008). As a result, high-school students tend to think of this method in these terms, as steps which remain unchanged (Leblebicioğlu, Çapkınoğlu, Metin Peten, Schwartz, 2020). The pre-service teachers’ ideas about how science is conducted may be due to misconceptions stemming from the textbooks they used in high school, as most of the sample in this study were in the first years of their university education. To believe that doing science is to do nothing but follow unchanging algorithms, and that these algorithms can be adapted to any subject can lead to misconceptions about the limits and methods of science. It may be that the pre-service teachers did not understand the concepts of science, and that this prevented them from correctly understanding the scientific method. On the other hand, according to Uyar (2016), even philosophers of science agree that there is as yet no universal criterion for determining the limits of science. Therefore, it can be understood why pre-service teachers would also have difficulties determining these limits.

Relationship between Factors

Different types of pseudo-scientific beliefs may reinforce each other. A person who has one type of pseudo-scientific belief may be more likely to have other types of such beliefs. According to Lindeman (1998), individuals believe in various pseudo-scientific notions as they meet many basic social needs and make it easier to explain and make sense of unexpected events encountered in everyday life. Pseudo-scientific beliefs are not inherently different from other beliefs, but many pseudo-sciences offer a vision of the world that is more coherent, controllable, and acceptable (Lindeman, 1998). Pseudo-physical Claims positively correlated with Changes in Scientific Knowledge and Socio-cultural Impact. The pre-service teachers who believe that scientific knowledge is changeable and subjective tend to reject pseudo-physical claims. Understanding the NOS makes it easy to properly distinguish between the pseudo-scientific and the scientific (McComas, Clough & Almazroa, 2000).

A negative correlation was found between Creativity and Imagination and Pseudo-medical Claims. Pseudo-science believers consider their beliefs to be scientific (Shermer, 2002). However, their pseudo-scientific “knowledge” often conflicts with proper scientific theories. They may thus place a lot of weight on the idea of Creativity and Imagination, as it supports their point of view. They also tend to believe that they themselves are able to think creatively and flexibly, and that they have a strong imagination. This may lead to them misinterpreting the role of creativity and imagination in science and becoming susceptible to pseudo-medical claims. Beliefs in, for example, alternative medicine are indicative of this. Those who believe that alternative medicine is a natural, creative and successful form of treatment are inclined to pseudo-medical beliefs about its effects.

Pre-service teachers who understand the role of scientific theories and laws have more pseudo-scientific beliefs. These teachers can also be affected by non-scientific knowledge in daily life (Saka & Sürmeli, 2017). On the contrary, some research has been found that as the level of education increases, belief in paranormal events decreases (Silva & Woody, 2022). However, according to Lindeman (1998), "the last decades' explosive increase of scientific information has not decreased popular belief in the pseudo-sciences". It may be the case that the continual increase in scientific knowledge makes science ever more difficult to learn and understand. The pre-service teachers may be choosing to turn to pseudo-scientific beliefs that offer simpler solutions instead of increasingly complex scientific knowledge because pseudo-science offers a more coherent, controllable, and positive view of the world.

This study has determined that the components of the NOS are correlated with, and reinforce each other. Having a sense of the role of creativity and imagination in science may provide an awareness of scientific method and the limits of science. Knowledge of the limits and postulates of science and knowing the role of creativity and imagination and in science may provide the capacity to discriminate between scientific laws and theories.

Differences between Fields and Gender

Snow and Collini (2012) stated that NSMT and SSAT cultures perceive science differently. In a study comparing pre-service social fields teachers and pre-service natural sciences, teachers were found to perceive science differently (Ürey, Karaçöp, Göksu & Çolak, 2017). Most pre-service SSAT teachers do not take any specific courses on the NOS during their education (Türk, et al., 2018). NOS is often associated with natural sciences due to positivism. And natural sciences are more associated with positivism than social sciences. Because natural sciences are more based on controlled experiments than social sciences. Therefore, they take more lessons from which they can learn NOS knowledge. In some NSMT departments, courses on the NOS or the Philosophy of Science may be taught as separate courses. On the other hand, in some SSAT departments, such courses are not be available. In the country where this study was conducted, the education system divides students in high school into two main groups after the 9th grade, a natural sciences group and a social sciences group. Specialized education at an early age can make it difficult for students to acquire the knowledge and skills that they should have in other fields.

The needs and priorities of females and males are different (Beşli, 2008; Doğan-Bora, 2005; Saraç & Cappellaro, 2015). Therefore, differences can be expected in the pseudo-scientific beliefs and beliefs about the NOS between males and females. Studies show that females have more paranormal beliefs, such as beliefs in precognition, spiritualism, witchcraft, psychics, and alternative medicine (Aarnio & Lindeman, 2005; Mencken, Bader, Stark, 2008; Mencken, Bader, Kim, 2009; Wilson, 2018). On the other hand, men are more prone to beliefs about aliens (Wilson, 2018). The results of this study do not show that. The types of pseudo-scientific beliefs were determined to be independent of the gender variable. Peltzer (2003) found similar results. The same is true for the components of the NOS. Although problems related to gender equality have decreased, they have not been fully eliminated. However, the decrease in gender stereotypes promoted or reinforced in education may explain the lack of a significant difference.

Conclusion

Understanding the NOS depends primarily on the correct learning of science-related concepts, such as laws, theories, observation, inference, etc. Failure to acquire these concepts as they are used in science causes the different meanings placed on them in daily life to prevail. If people's understanding of the basic concepts of science is improperly structured, then their entire sense of what science is will be wrong. It is especially important that pre-service teachers have the correct understanding, because they are responsible for passing on this knowledge to future generations.

The changeability of scientific knowledge is often misinterpreted. Not understanding the nature of scientific theories and not understanding that scientific knowledge is changeable are mutually reinforcing. This leads people to question theories based on scientific knowledge. Perceptions about the subjectivity of scientific knowledge also support these misinterpretations. This may then reduce individuals' reliance on scientific knowledge, causing them to turn to pseudoscientific information as alternative information. The main problem is that people may think, "Theories are only assumptions. They are not proven and they can change. Also, the findings of scientists are subjective. So, claims that are today called pseudo-scientific claims may one day become scientific knowledge." This is to misinterpret and misunderstand how specific concepts are used in science. It is a very dangerous way of reasoning, leading to false and inappropriate conclusions.

Having any kind of pseudo-scientific beliefs makes it more likely to have other pseudo-scientific beliefs. One of the reasons for the spread of pseudo-scientific beliefs is that society finds science increasingly complex and difficult to understand. It is critical that science educators simplify scientific information and present it to the public in an appropriate. Social awareness of the unscientific nature of some topics, such as astrology, has increased through the work of science educator. However, this awareness remains insufficient, and many pseudo-scientific beliefs, particularly pseudo-medical beliefs continue to persist. For example, folk remedies are still commonly used.

The pre-service teachers in NSMT areas were slightly more fortunate than the SSAT colleagues. The education they have received provided them with a better understanding of the concepts related to the NOS, although it did not protect them from believing in some pseudo-scientific claims. However, understanding these concepts alone is insufficient to understand the NOS and to be able to distinguish what is scientific from what is not. Although the NSMT pre-service teachers had a more accurate knowledge of the concepts, they had trouble interpreting them. On the other hand, contrary to many scientific studies, the fact that in the current study the gender variable did not affect beliefs about the NOS and pseudo-scientific beliefs may indicate that this knowledge and the ability to discriminate can be provided to both genders in the same way.

Limitations and Recommendations

The main limitation of this study was that COVID-19 restrictions prevented additional data-collecting methods, such as interviews, from being used. A number of practical problems limited the sample size. Many pre-service

teachers could not be reached. Therefore, the number of pre-service teachers in some disciplines was limited in the sample.

Studies focused on the components of the NOS can make it easier for people to acquire scientific literacy. This will help the number of pseudo-scientific beliefs prevalent in society to be reduced. Teachers and pre-service teachers play a significant role in this. In their study, Mıhlandız and Doğan (2017) concluded that inadequacies in the teaching of the NOS were due to low a level of self-efficacy. It can be recommended that the NOS should be taught as a separate course in teacher education programs. The history of pseudo-science also offers an ideal opportunity for teaching the NOS (Allchin, 2004). As well as attending to this recommendation in the literature, the results of this study suggest that a separate NOS course, including examples of the differences between pseudo-science and science, should be included in high school. In addition, the specific features, concepts and limits of science should be emphasized in this course. It was an expected result that science-related concepts and knowledge of the NOS that were independent of gender variables were more common in NSMT fields. However, basic education on the NOS should also be provided in SSAT subjects.

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Appendix

Scale 1: Pseudo-scientific Beliefs Scale (PSBS)

1. Some people can transfer their thoughts to another person with the power of their minds.
2. Some people can move objects with the power of their minds.
3. Flying vehicles from other planets come to visit the Earth.
4. When the mind is sufficiently focused, objects can be levitated.
5. Extraterrestrials visit the Earth.
6. It is possible to design machines that can produce infinite energy when you start.
7. It is possible to bend metal objects such as spoons from afar with just the power of the mind, without applying physical force.
8. Structures such as the pyramids were built by beings who visited the Earth in ancient times.
9. Some people have the ability to see what's going on in remote areas without leaving where they are.
10. It is possible to predict the gender of an unborn baby by dangling the wedding ring of the pregnant women from a piece of string or rope.
11. Horoscopes are based on science.
12. Some people can accurately tell a person’s future by looking at the palm of their hand.
13. Fortune-telling and predicting the future are based on science.
14. Some numbers can that bring luck to people.
15. A person’s future can be accurately determined by observing celestial bodies.
16. A polygraph is a technological tool that gives precise results and is based on sound scientific foundations.
17. There are many effective treatment methods that doctors do not use.
18. It is possible to cure certain diseases by massaging specific areas of the soles of the feet.
19. It is possible to identify diseases by examining the strength or weakness of the muscles.
20. It is possible to treat cancer in non-medical ways.
21. Each of the organs in the body is associated with certain areas on the soles of the feet.

Scale 2: Nature of Science Beliefs Scale (NOSBS)

1. If knowledge is scientific, it has been proven definitively and is no longer subject to change.
2. A student who says "The object I released fell to the ground" is expressing an observation they have made.
3. There is only one scientific method that scientists follow in order.
4. Scientists use their creativity and imagination to reach conclusions from the data they have.
5. Science deals only with directly observable events.
6. Science is dependent on social values (political, religious, philosophical, etc.) and is affected by these values as it develops.
7. Science is based on the assumption that the workings of nature can be understood.
8. Even if scientific research is done correctly, the information obtained as a result of this research may change in the future.

9. If different scientists have the same data, they will reach the same conclusion.
10. Scientific theories are explanations based on specific assumptions about entities that cannot be observed directly.
11. After scientific theories are proven and accepted by scientific circles, they turn into scientific laws.
12. The personal feelings and thoughts of scientists do not affect the results they reach in their studies.
13. A student who determines that nitrogen gas has the properties of compression and expansion, is expressing an observation when they say, "Nitrogen gas has a void structure".
14. Scientific laws are scientific claims that have been conclusively proven.
15. If a conclusion has been reached through scientific experiments, this conclusion is absolutely correct.
16. Science cannot answer all questions about human life.
17. Creativity and imagination are also used in scientific studies.
18. Scientific studies are influenced by the cultures and value judgments of societies.
19. Different scientific methods are used in different branches of science.
20. Scientists are now absolutely sure of the cell theory they have developed.
21. A student who says that the object he releases "falls due to the force of gravity" is expressing an observation.
22. A claim that cannot be directly tested cannot be scientific.
23. As new scientific theories are put forward; scientists can change their claims by reinterpreting the data they have.
24. Scientists use their creativity and imagination only when designing their experiments.
25. A student who says, "When you hold a metal spoon to a heat source, it gets hot" is expressing an observation.
26. Science is based on the assumption that scientific laws apply equally throughout the universe.
27. Scientific theories are used to explain the phenomena covered in scientific laws.
28. Science can find answers to all the questions we can think of.
29. Science consists of the systematic observation of entities, events and processes.
30. Scientific knowledge changes only as technology develops.
31. Scientific theories can be tested directly.
32. To reach the right result in scientific research, the steps of determining the problem, collecting data, forming a hypothesis and experimenting should be followed in order.
33. To be successful, scientists act without prejudice (religious, cultural, philosophical, etc.) and work independently of personal values.
34. Only natural factors are included in scientific explanations, supernatural powers (God, angels, etc.) are not mentioned.
35. A scientific theory attempts to explain the cause of certain events.
36. Supernatural beings such as genies and angels cannot be the subject of science.
37. Creativity is required to create explanations such as the orbits and energy levels in the "Bohr Model of the Atom".

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Student Teachers' Perceptions of their Development of 21st Century Competencies

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Abstract

Changes in science and technology and future employment competencies are needed for lifelong learning necessity cultivating students' development and progress in 21st century competencies. The purpose of the study was to examine Jordanian student teachers' perceptions of whether their teacher education had prepared them for 21st-century competencies, and how well they applied these competencies to their classroom teaching. The study also identified best practices, major obstacles, and suggestions for achieving these competencies. The study was conducted in two universities in the South and three universities in the North of Jordan that offer teacher education programs. A mixed-methods approach was used for this study. The sample consisted of 457 Student teachers who completed a structured questionnaire with open-ended questions to assess 21st-century competencies. Quantitative data analysis relies on descriptive statistics and correlations, while qualitative data analysis relies on content analysis. Despite differences in competency, the student teachers achieved 21st-century competencies based on their self-assessment. Students' perceptions of whether they succeed in implementing 21st-century competencies in their classrooms were documented in this study. The best-achieved competency was collaboration, and the least well-achieved competency was global connections. Answers to open-ended questions provided convincing evidence that courses involving collaborative and interactive learning, high quality, sufficient support, relevant 21st-century competencies, and integrating theory and practice can contribute significantly to the development of student teachers' 21st-century competencies.

Introduction

The essential need for students' 21st century skills has been recognized around the world. Many scholars (Anderson & Krathwohl, 2001; Bandura, 1997) have emphasized the necessity of instructors being prepared and educated to help their pupils' gain 21st century skills. Teachers must be knowledgeable with these skills and allowed to apply them in their classrooms. We studied student teachers' perceptions of their performance in obtaining 21st century competencies in their teacher education programs, as well as how well they implemented these qualities in their classrooms, in this study. Furthermore, the survey requested students' opinions on the best practices, main roadblocks, and recommendations for acquiring 21st century.

Theoretical Framework

Teaching and Learning Skills for the Twenty-First Century

Changes in science and technology and future employment competencies are needed for lifelong learning necessity cultivating students' development and progress in 21st century competencies. Cisco, the OECD, and the EU are just a few of the big information and communication technology (ICT) companies and international organizations that have started programs connected to 21st-century skills. These projects are designed to prepare students for job in the twenty-first century. The importance of defining future competencies has been emphasized (Greenstein, 2012; Hyslop, 2011; Beers, 2011; Darling-Hammond, 2006). This concept isn't new. Even in the 1970s, UNESCO published a report on 'Learning to be' (Faure et al. 1972 as cited in Pantic and Wubbels, 2010), sparking a debate on how vital it is to educate people for future needs. However, the situation is difficult, and there have been some critical voices voiced (Toom, 2017; Voogt and Roblin, 2012). The dominance of technology firms in education without actual linkages to local teaching and learning contexts, as well as the growth of neoliberal policies in education, has been major issues. Skills and competencies have limitations as well: they might be too broad or too limited, and they may not fully comprehend human growth and development. However, politicians and educators in most countries recognize the necessity of preparing people for change. As a result, Jordanian curricula use terms like 21st-century competencies, generic skills, transferable skills, and transversal competences to describe 21st-century competencies (Bani Amer, 2021; Voogt and Roblin 2012; Westera, 2001). Regardless of nomenclature, all countries strive to equip students with 21st-century skills in order to cope with current and future changes, which set high expectations for the entire educational system (Whitty and Willmott, 1991).

There has also been fear that these abilities will become normative curriculum standards, demanded and controlled by today's politicians, without a deeper examination of their value for people's lives and well-being, and without significant reforms in schools. Because 21st-century competencies are not discrete abilities but are integrated with all teaching subjects and activities in schools, according to Westera (2001, he necessitates fundamental reforms in schools and teaching culture. As a result, the teachers' ability to work toward these goals in practice is critical, and reforms in teacher education are also required. Our research intends to offer new insights into how these skills might be learnt and acquired in teacher education.

Future competencies are viewed as broad and inclusive in this study, encompassing more than just a direct link to technology and the market economy. As a result, both teachers and students are finding it increasingly difficult to teach and learn. Teachers are supposed to do more than just impart knowledge to pupils; they are also required to assist students in developing into self-sufficient, responsible citizens with future competencies and capabilities.
Researchers (Ravit, 2014; Shavelson, 2013) examined the main programs focusing on 21st-century competencies; and key competencies of the European Union. Despite their differences in emphasis and focus, the frameworks share common competencies in four areas: (1) technology, ICT literacy; (2) relating to others, including communication and collaboration; (3) personal abilities, including creativity, critical thinking, and self-direction; and (4) in relation to society and the world, including global and local citizenship, social and civic responsibilities, and so on.

In this study, competency conceptualization relates to Niemi (2015) and Struyven & Meyst (2010)'s work on professional development in project-based learning and support for students' development of 21st-century skills. The eight categories in the research above encompass a wide range of critical competencies that can be found either officially or implicitly in the definitions of 21st-century competences. On request, the associated author can provide more information, including definitions, as well as other specifics of the findings specified in the text with a Teachers' opinions of how successfully they gained 21st-century abilities and how well they used them to their teaching were two significant components of the study. The same poll was used to assess teaching in the twenty-first century (Lee and 2018).

Critical thinking, collaboration, communication, creativity and innovation, self-direction, global connections, local connections, and using technology as a tool for learning were among Korthagen's (2017) skills. Almost all of the 21st-century frameworks discussed before define the first four competencies. Self-direction is an important competency that entails guiding oneself, regulating one's own behaviors, and accepting responsibility. It is referenced openly or implicitly in several 21st-century competency frameworks. ICT literacy is a broad notion that is described in all 21st-century paradigms as the ability to use technology as a tool for learning (Bani Amer, & Al-Khataybeh, 2022).

Other 21st-century competency frameworks did not expressly specify global and local connections competencies, but they were implicitly indicated in all 21st-century frameworks' social responsibility and citizenship (local and global) competences (Lee and Tan 2018; Voogt and Roblin 2012). The world is highly interconnected as a result of the rapid development of telecommunications, modern transportation, and the global economy. Students' global and international perspectives can be shaped by education (Häkkinen et al, 2017; UNESCO 2013, 2014; Hixson and Whisman, 2012; Korthagen, 2004). The necessity of internationally competent citizens who communicate productively and respectfully with others and take responsible action towards sustainability and collective wellness has been highlighted by the (Caena, 2014).

Integrating Theory and Practice in the Development of Teacher Competency

Various techniques to developing teacher competency exist, both during TE and in the profession as a whole (ATC21S, 2012; Blömeke and Delaney, 2012; Ball, 2000). Teacher competences, according to Westera (2001), have two dimensions: a knowledge component and a skillful behavior component. It includes the ability to put such information and skills into practice in the workplace (Toom 2017). The willingness to apply competencies appropriately in real-life circumstances is also important (Blömeke & Delaney 2012). Performance - the capacity to know and be able to act or perform – was identified as a significant aspect of competency by White (2013). The ultimate purpose of TE programs is to prepare teachers to apply what they've learned to a variety of situations. Blömekeet et al (2015) and Caena (2014) stated that the ultimate purpose of TE programs is to prepare teachers to be able to apply their knowledge to a variety of teaching contexts. The importance of putting theory to practice in teacher professional development was stressed by Snape (2017) and Darling-Hammond (2017). Schulz (2008) emphasizes the need of combining knowledge and action. Others noted the integrative idea, which encompasses knowledge, skills, decision-making, and the ability to respond in professional tasks and situations, as well (Griffin

and Care, 2012; Weber, 2011; Deardorff, 2009). As a result, learning theories can help student teachers build their competency; nevertheless, increasing and deepening their learning through practice is equally vital. Teachers internalize competences through absorbing knowledge and theories and implementing what they have learned (AL-Khataybeh& AL-Awasa2016).

This study looked into student teachers' perspectives of gaining 21st-century TE competencies as well as how they used those competencies in their classrooms. Gender inequalities as well as variations in student teacher perceptions at universities and universities of applied sciences were explored. In addition, we looked at the best practices and main roadblocks to gaining 21st-century skills.

Teacher Competency Development in Jordanian Education

This research focuses on Jordanian Teacher Education. Programs equip student teachers to implement Jordanian educational objectives, encourage learners' growth as ethically responsible members of society, and facilitate the attainment of future skills (Al-Khataybeh & Al-Tarawneh, 2017). Transversal competencies, which are a more extensive form of 21st-century competencies, are included in the most recent national core curricula for various educational levels. This means that student teachers' and teachers' 21st-century skills are critical in assisting students in reaching their goals. In the Jordanian teacher education program Bellanca& Brandt (2010) offered a theory-based pedagogical framework for teacher education's 21st-century learning practices, which included the process and tactics for collaborative problem-solving skills and strategic learning skills. According to Niemi (2018), student teachers rated themselves as skilled learners, particularly in the areas of collaboration, teamwork, and learning methodologies.

All primary school teachers in Jordan must complete a five-year academic master's degree program. The term university refers to colleges and universities that offer bachelors, masters, and doctoral degrees in a variety of subjects (Bani Amer & Baarah, 2021). Academic studies, pedagogical studies, including teaching practice, communication, and ICT, and research studies for bachelor's and master's these are all part of university TE programs (Al-Khataybeh, 2020). Pedagogical studies are also available at universities of applied sciences, mostly for vocational school and adult education teachers.

These students have completed academic subject studies in their previous BA and MA studies at universities or applied universities of applied sciences, or have a tertiary-level degree of three or three years of relevant studies in their field in some situations. Furthermore, they must have at least three years of work experience before applying to TE in most situations, which is not required of university student instructors. As a result, university student teachers are frequently younger. At both sorts of universities, teaching practice is divided into numerous phases that widen and strengthen student teachers' competences while being overseen by qualified teacher educators. Both sorts of institutions' 60-credit pedagogical courses have the same goals: to help student instructors become self-sufficient and responsible professionals. Institutions, on the other hand, are more concerned with research and the discovery of new knowledge, whereas universities of applied sciences are more concerned with practical projects with regional partners.

Questions of Study

Using the following research questions, this study sought to determine how Jordanian student teachers evaluated their learning of 21st-century competencies and how successfully they used these competencies to their teaching.

1. What are student teachers' perceptions of their 21st-century competency development in TE, and are there any gender or university type inequalities among student teachers?
2. What are student teachers' opinions of how well they implemented their 21st-century abilities in practice, and are there any gender or university type differences among student teachers?
3. What are the connections between TE competencies and teaching practice, as well as between TE competencies and practice competencies?
4. What are the student teachers' thoughts on best practices, main roadblocks, and suggestions for assisting their learning of 21st-century skills?

Method

Data Collection and Participants

A mixed technique approach was adopted in this investigation. Between December 2021 and June 2022, data was voluntarily collected online from student teachers at two Jordanian institutions and three universities of applied sciences. Participants were informed about confidentiality and autonomy at the start of the data gathering process. There were 457 total responders, with 55 percent from the two participating universities and 45 percent from the three participating universities of applied sciences; 24 percent were male student teachers and 76% were female student teachers. 12 percent of the student teachers wanted to be kindergarten teachers, 14 percent wanted to be class teachers, 21 percent wanted to be subject teachers, 8 percent wanted to be special education teachers, 30 percent wanted to be vocational education teachers, and 15 percent wanted to be other teachers, mostly in higher education.

The Study Instruments

The questionnaire had already been validated using scores ranging from 1 to 5 in previous studies. The questionnaire for this study was translated from English to Jordanian, and the translation was double-checked by three experienced researchers who are fluent in both Jordanian and English. The number of competencies and item questions, as well as their definitions, remained unchanged. As in prior studies, the scale for student teachers' self-assessment of their competences ranges from 1 to 5. However, because the original instrument was designed for schoolteachers, the major questions were changed to suit student instructors, and background information questions were added. Greenstein agreed to let the questionnaire be used in this study. The instructions for the questionnaire were as follows:

Part A: How effective were the TE program studies (including pedagogical and subject matter studies) in assisting you in achieving the following competencies?

Part A of the critical thinking competency has six items, one of which is: 'Has assisted in comparing information from various sources when completing tasks or assignments.'

Part B: Based on your own teaching experience, please assess your competencies (e.g. from teaching practice or other teaching situations).

Part B of the critical thinking competency has three elements, one of which is: 'I can use ways to help my students improve their critical thinking skills.' 'I do not have any teaching experience yet,' is an option in Part B.

Open-ended questions about best practices and main barriers to obtaining 21st-century abilities, as well as suggestions for helping student teachers' learning of 21st-century competences in TE, were used to collect qualitative data. All of the inquiries covered both subject matter research and pedagogical studies that included teaching practice:

Question 1: Please tell us about your best or most memorable experience learning 21st-century skills.

Question 2: Please describe any notable challenges or roadblocks you encountered when learning these skills.

Question 3: How can your institution or teacher educators assist and support you in the development of those skills?

Cronbach's Alpha analysis of our study's reliability analysis revealed that the reliability scores for teacher education ranged from.886 to.926, while the scores for teaching in practice ranged from.828 to.912. For each skill, a complete item reliability analysis was also calculated. Before collecting data, the questionnaire was pre-tested and double-checked with five student teachers. The questionnaire was uploaded to the web system after many linguistic checks.

Data Analysis Methods

The mixed method strategy was adopted in this investigation. Descriptive statistics and correlations were employed in quantitative data analysis. The mean value and standard deviation of the student teachers' perceptions of how well they mastered their competences are determined by descriptive statistics. Gender disparities among student teachers, as well as differences between student teachers from universities and universities of applied sciences, were compared using the t-test. Correlations were used to describe the relationships between the student teachers' competencies learned in TE and their teaching in practice.

Content inductive analysis was used to extract crucial information from qualitative data; this analysis complements quantitative data by allowing students to better comprehend their quantitative assessments (Nitko & Brookhart, 2007). Two experienced researchers used content analysis to analyze the qualitative data and then discussed the findings to arrive at a synthesis in the data interpretation. Courses, teacher educators, teaching method/learning settings, and learning techniques were identified as key contributors to student teachers' development of 21st-century competences through inductive content analysis. We wanted to see how these factors influenced the student teachers' ability to develop 21st-century skills. We also wanted to figure out what was preventing them from learning.

Results

Competencies Learned in Teacher Education and Disparities in Demographics

The first research question was about student teachers' perceptions of their 21st-century abilities gained through TE and teaching practice. Six of the eight competences had mean values ranging from 3.20 (SD =.84) to 3.73 (SD =.78) based on descriptive statistics analysis [*]. Collaboration (M = 3.73, SD =.78) and critical thinking (M = 3.50, SD =.71) were the best-achieved competences. 'Global connections' (M = 2.58, SD =.94) and 'Local Connections' (M = 3.01, SD =.92) were the least well-achieved competencies.

The t-test [*] was performed to discover gender and institution differences using the means and standard deviations. Male student teachers had somewhat higher mean values than female student teachers, but no significant gender differences in any of the eight competences emerged. Collaboration (p =.04*), communication (p =.02*), creativity & innovation (p =.02*), self-direction (p =.00**), and using technology as a tool for learning (p =.02*) were shown to be significantly different among student instructors from both types of universities. Student teachers from universities of applied sciences had greater perceptions of competencies than student teachers from universities.

Demographic Variations and the Competencies Used in Teaching

For the second research question, we discovered that when instructing students in a classroom, student teachers successfully implemented almost all of their 21st-century abilities [*]. Seven of the eight competences had mean values ranging from 3.24 (SD =.78) to 3.78 (SD =.65). 'Collaboration' (M = 3.78, SD =.65) and 'Using technology as a tool in learning' (M = 3.6, SD =.78) were the most commonly used competencies. 'Global connections' (M = 2.9, SD =.95) were the least used competencies in practice, as previously stated. All mean values were slightly higher than the student teachers' views of what they had learnt in their TE when it came to competency application. We used the t-test to examine the means and standard deviations of competences to see if there were any variations by gender or institution. Male student instructors had slightly higher mean values than female student teachers. Except for self-direction (p =.01**) and using technology as a tool for learning (p =.04*), there were no significant gender differences in most of the eight competences. Significant differences in five competences were found when student teachers from both types of university were compared: critical thinking (p =.01**), communication (p =.02*), self-direction (p =.00**), global connections (p =.02*), and local connections (p =.00*). The discrepancy in impressions could be due to the fact that student teachers in institutions of applied sciences are expected to have at least three years of work experience, which facilitates familiarity with particular competences in the field.

Relationships between TE Learned Skills and Their Use in Practice

The third study topic focuses on the connections between TE competencies and teaching practice, as well as the connections between TE skills and practice competencies. The eight competencies gained in TE (ranging from.41** to.74**) and applied in practice (varying from.31** to.58**) have high linkages. Between the eight competences learned in TE studies and the eight competencies implemented in practice, statistically significant

correlations (ranging from.34** to.42**) were discovered [*]. As a result, student teachers' study of 21st-century TE abilities and their application in the classroom are significantly connected. The domain of global connections had the strongest competency correlation between competency obtained in TE and competency applied in practice (r =.42, p 0.01).

Best Approaches for Developing 21st-Century Competencies

The following are the categories that emerged from our review of best practices: (U-ST represents student teachers from universities, and UAS-ST represents student teachers from universities of applied sciences in Jordan). Collaborative learning is when students learn with and from one another in a group setting.

Collaborative learning, which includes group work, teamwork, peer learning, co-teaching, learning communities, networking, and sharing, was cited by 82 respondents as the greatest way to enhance their 21st-century competencies. Students learned best when they interacted with one learning both from and with one another. As two comprehensive universities (U-ST) student instructors put it:

> 'It is most rewarding to work as a group.' (U-ST1)
>
> "The most satisfying aspect of collaboration... [You] share ideas and seek guidance from fellow students and lecturers... "(U-ST2)
>
> "The best experience is studying in diverse groups" according to another comment. A strong sense of belonging exists. We help and support one another. For me, this type of learning opportunity was quite valuable." (U-ST3)
>
> The same observation was confirmed by a number of student teachers from universities of applied sciences (UAS-ST).

For many years, teacher education in Jordan has emphasized the value of collaboration and shared learning, which appears to be especially helpful for developing 21st-century skills.

Practicing and Deepening Competencies

Teaching practice, according to several student teachers (n = 79), is the best practice for gaining 21st-century competences.

> "The best practice is during the training period [teaching practice time]!" said a student teacher. There, you can experiment and get practical instruction [from a supervising teacher]" (U-ST4).
>
> "I got the essentials [of those competences] via classes, then deepened [them] in teaching experience," said another student teacher. (U-ST5)

There Are Several Courses That Are Essential

The quality of the courses on offer was complimented by several students (n = 76). Technology applications, media, the internet, animations, and coding classes were all deemed essential.

> "We employed several different digital tools in one pedagogical course," one student instructor said. The

animation was engaging, entertaining, and motivating." (U-ST6)

"ICT skills have been this kind of 'aha' experience that I still appreciate and remember," she says of learning to utilize digital tools (U-ST7).

Learning about digital tools was seen by several students as "the most valuable thing I have experienced during my education" (UAS-ST1).

Certain teaching approaches and subject, such as didactic, educational psychology, history, art, and handicraft, were mentioned by student teachers as being beneficial in developing their 21st-century competences. The importance of collaboration, which includes intensive talks and sharing, such as via group chat, was emphasized in the course descriptions, which included comments on teaching approaches. The value of learning communities was emphasized through student teachers' experiences. Student teachers appreciated active learning procedures such as recording films, audio essays, analyzing past teaching situations, and project- and problem-based learning as a result of the opportunity to engage and integrate knowledge and practice.

Major Roadblocks to Student Teachers' Development of 21st-Century Skills

We also looked at the primary roadblocks to student teachers developing those skills. 188 student teachers out of 272 detailed their experiences, with 8.5 percent (16 out of 188) claiming there were no hurdles. The three major issues that were identified are listed below.

Time, Practice, and Resources Are in Short Supply

The most frequently reported stumbling block was a lack of time (25 of 188 respondents). Insufficient practice and resources, such as computers, cameras, 3D printing, software licenses, various programs, digital skills, and a lack of resources, were also noted.

"It's either a lack of time or a lack of resources." (UAS-ST2), (UAS-ST3), (UAS-ST4), (UAS-ST5)

"What is taught is not put into practice." (U-ST8).

Some Educators Lack the Necessary Resources and Skills

Barriers to learning were also highlighted, which were related to teacher-educator abilities such as insufficient competency or motivation, old-fashioned teaching methods, and mass lectures. Teacher educators would have needed to provide additional assistance to student teachers, particularly in regards to their unique needs or differences. Too many things happening at once, too much course content, too little training, unclear information, and a lack of skill integration were all cited as issues in some courses. Students also highlighted poorly organized group work, such as extremely large groups, inadequately clear group work instructions, continually changing study groups, too much time spent on group meeting scheduling, and delivering feedback in a large group.

Some claimed that 21st-century skills were not adequately taught:

"...these talents are not taught in a systematic, consistent, or thorough manner, but rather through the acquisition of other skills... and abilities aren't properly assessed..." (UAS-ST9)

Fear, a Negative Attitude, a Lack of Confidence, and a Lack of Desire

One intriguing conclusion is that student instructors' self-reflective comments on their own progress are as follows: 7 individuals lacked drive, 5 lacked courage or initiative, and 2 lacked self-confidence in their ability to learn or were unsure of their own abilities.

> "The largest roadblock is my own fear of putting [those skills] to the test in a fresh environment." (UAS-ST8)
>
> "It's likely that your own self-perceived attitude is the largest impediment [to obtaining 21st-century skills]." (UAS-ST9)

Suggestions for Acquiring 21st-Century Skills

The student teachers were asked for advice on how to support their students' learning of 21st-century skills in TE. 191 responses were received from the 272 respondents, and 191 of them fit into the following categories, supporting our previous conclusions.

Collaboration in the Classroom and Learning

More cooperation with colleagues/peers, co-teaching opportunities, and opportunities to share experiences with other student teachers were among the ideas, which aligned with prior best practices.

> "Small groups can practice 21st-century learning and teaching competencies." (U-ST9)

Courses and Teaching Techniques Those Are Specific

More courses in 21st-century competencies, psychological aspects of learning, using various technology/ICT/digital tools in various teaching situations, online learning and teaching, dealing with challenging situations at school (e.g. bullying at school, interaction with parents), and interaction skills, as well as more teaching practice, were requested by student teachers.

> “Learning and teaching of such competencies in a more detailed, systematic, or complete manner” (UAS-ST6). "How to teach those competencies that is intertwined with a certain subject/field" (U-ST10)
>
> "Some university teaching is outdated; it needs to be updated for the twenty-first century." (U-ST11)
>
> "Learning by teaching those competencies could be a good approach to learn them; this could be tried out in small groups." (U-ST12)

Bringing Theory and Practice Together

"I expect that we will have more concrete tools and procedures in building those competencies," said one student teacher, "I hope that we will have more concrete tools and methods in developing those competencies... Not only do us need to know why and what, but we also need to know how... We understand the theory, but we don't learn how to put it into practice in the classroom."

"Exams do not aid in the acquisition of competencies; they should be based on real-life scenarios." (U-ST13)

"Those competencies should be included into instructional methods and exercises so that student teachers may put them into practice in the classroom later." (U-ST14)

“More practical approaches and ways of putting the theory into practice” (U-ST15)

Continual Education

Student instructors emphasized the need of continuing education and growth, including additional training, more particular competency courses, more practice, and a deeper dive into the competencies.

"It takes time to develop those skills; it's a never-ending process." I'd like to delve deeper into studying and teaching such skills." (U-ST16)

'After graduating from university, more training is still required.' (UAS-ST13)

"The TE program taught me that there is no such thing as too much or too little learning; there is always something fresh to learn." (U-ST17)

"You can constantly progress and never be so-called ready in any competency!" I'm eager to learn new things and to improve on what I've already learned." (U-ST18).

Discussion

According to the student teachers' self-evaluations, TE provided excellent training in 21st-century skills. Many variables may have played a role in this excellent outcome, including the Jordanian education system's strong focus on 21st-century capabilities in the most recent national core curriculum (Hyslop, 2011) and teacher education programs. Another issue to consider is the quality of teaching practice, which involves several stages and is linked to theoretical research. A third likely element is the long history of Jordanian TE in supporting the development of competences and social-emotional skills, as teaching entails daily interaction with people. The high caliber of candidates admitted to TE in Jordan is a fourth possible cause (Schulz, 2008). On a theoretical and teaching practice level, however, the competencies of 'Local connections' and 'Global connections' remain lower than other competencies. In the future, these two skills will require more development. By integrating the learning in TE and in teaching practice, this study proved the value of student teachers' competency learning. Caena (2014) emphasizes the significance of combining knowledge with action. Several other researches (Korthagen, 2017; Hixson & Whisman, 2012; Westera 2001) agree that integrating knowledge and skills in professional tasks and circumstances is critical. This was evident in the comments of the student instructors. The greatest strategy to learn and improve competencies is to combine theoretical learning with practical application.

The most efficient form of learning, according to both quantitative and qualitative evidence, is to combine theoretical learning with the application of 21st-century competencies. This is a never-ending process. High relationships between competences obtained in TE studies and in practice were discovered. This necessitates that the entire TE system, as well as its culture, actively nurture these skills (Lee & Tan, 2018).

We determined that student teachers learn from and with one another through group work, teamwork, peer learning, collaborative learning, co-teaching, learning communities, networking, and sharing based on the qualitative data. This discovery is consistent with Lee & Tan (2018) social-cultural theory, which states that learning is a socially and culturally connected process that occurs when people interact. The competency of collaboration was assessed with the highest scores among the eight competencies in this study, according to both quantitative and qualitative data based on student teachers' self-assessment. This backs up previous research on Jordanian student teachers' acquisition of 21st-century skills (Häkkinen et al. 2017).

Many positive aspects of TE were mentioned by student teachers, including how group work helped pupils gain 21st-century skills. Smaller group numbers, clearer directions for group work, and finding appropriate time slots for group work are still needed to maximize the benefits. More integration of theory and practice, (2) more courses containing 21st-century competencies and (3) courses with teaching methods that include students in active roles and collaboration were also suggested as enhancements. More time for student teachers to enhance their skills is also required. Student teachers gained knowledge from both their courses and their teacher educators; yet, one barrier to their learning was a lack of assistance from teacher educators.

In conclusion, the Jordanian student teachers successfully attained their 21st-century skills in both TE and instructional practice, according to self-assessment. There was no difference in perceptions between female and male student teachers. In terms of university types, student teachers from universities of applied sciences had slightly higher views of practically all competences and significantly higher perceptions of certain competencies than student teachers from universities. Furthermore, student teachers believed that group work, in which they learned from and with one other, certain courses and teacher educators, and teaching practice were the greatest places for them to develop 21st-century competencies. Too little time, insufficient resources, insufficient support from teacher educators, and insufficient teaching approaches in some courses were the biggest roadblocks.

Conclusion

Paying more attention to competencies of Local and Global connections, facilitating effective group learning opportunities; improving teacher educators' own competencies; integrating theoretical learning and practice; making competency development more visible by defining them in learning outcomes and offering more specific courses are some implications and suggestions for teacher educators that may support the development of student teachers' 21st-century competencies. This study demonstrates the importance of teacher education programs in developing student teachers' 21st-century abilities. Through group work and instructional practices, teacher educators play a critical role in assisting student teachers in learning competences and enabling them to be engaged learners. Although this research was conducted in Jordan, the concepts can be applied overseas to improve student teachers' 21st-century abilities, such as students learning from and with one another through group work, combining knowledge and action through teaching practice. Student teachers must also become aware of competence learning, develop good attitudes toward continuous learning, and develop learning to learn skills so that they can always begin learning a competency when needed.

Future Research and Limitations

This study's conclusions are exclusively based on self-reports. External observation and assessments from other parties would aid in the verification of the outcomes. Because only the most active student instructors replied, the voluntary and online replies may be skewed. Further research could track the development of student teachers after graduation, while they are teaching in schools. Similar studies could be carried out in other nations to acquire a better grasp of how 21st-century skills emerge.

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Bibliometric Analysis of Scientific Creativity Studies in WoS and Scopus Databases

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Abstract

The purpose of this study is to examine the trends in recent years by focusing on the bibliometric results of previous studies on scientific creativity. For this purpose, a total of 370 publications on scientific creativity obtained from Web of Science and Scopus databases were examined in terms of different bibliometric variables, and they were presented with visuals and tables. Bibliometric analyses of the publications in both databases were performed separately. Afterwards, a comparison of the top 10 studies that stand out in terms of scientific creativity studies in both databases was made and they were integrated with each other. Tables and images were created using the VOSviewer package program. The results of the study showed that the most frequently used keywords in research in both databases were "scientific creativity" and "creativity". In both databases, the countries that had the highest number of studies and whose scientific studies were most cited were determined as USA and China. In addition, it was also determined that the top three most cited authors in scientific creativity studies in both databases were D. K. Simonton, W. Hu, and R. J. Sternberg.

Introduction

Creativity is the ability of every individual to create a new product by using their imagination and it is a process that can be developed with the appropriate training (Kilic & Tezel, 2012; Rawat, Qazi, & Hamid, 2012). It will be difficult for societies consisting of individuals who cannot use their creativity and reveal their original ideas to move forward in the modern world (Denis Celiker, & Balim, 2012). Creativity is an individual trait that allows people to adapt to the environment in which they live and to improve themselves (Yurdakal, 2019).

While creativity has been considered a concept used in the art for many years (Denis Celiker, & Balim, 2012), different definitions have been introduced to the concept of creativity used in science (Koray, 2004). Although scientific creativity is an important concept both individually and socially, there is no single definition of it (Demirhan, Onder, & Besoluk, 2018). According to Aktamis and Ergin (2007, p.13), scientific creativity "depends on what steps are used when developing a new product or developing an existing product, how the problem is solved, and how the problem is recognized". In addition, scientific creativity can be defined as sensitivity to problems and problem solutions, understanding the fascinating nature of science, and developing new, extraordinary, and useful scientific information, experiments, theories, and products (Usta & Akkanat, 2015).

In the 21st century, scientific creativity is both the condition of life and the skill expected to be found in individuals (Kirana, 2020). In order for societies to constantly develop and adapt to changes, their individuals need to have scientific creativity (Sternberg, 2010). Scientific creativity allows individuals to integrate information that exists in everyday life, create solutions to problems encountered, and bridge between daily life and their knowledge (Lin, Hu, Adey, & Shen, 2003). As well as the role of an observer during research, individuals who are allowed to use their scientific creativity can recognize others that may be missing (Meador, 2003).

Structuring and solving problems encountered is a process of creativity. Therefore, individuals who can use scientific process skills in the problem-solving process are considered to have more scientific creativity (Bakac, 2018; Hu & Adey, 2002; Mumford, Reiter-Palmon, & Redmond, 1994). The fact that scientific process skills, problem-solving skills, and scientific creativity are related to each other in the science course (Aktamis & Ergin, 2007; Cheng, 2004) shows that science education and scientific creativity have a common point (Liang, 2002). Therefore, the scientific creativity of individuals is expected to increase as their academic achievements in terms of education levels and science studies increase (Demirhan et al., 2018). When the studies in the literature were examined, it was observed that as students' achievements in science class increased, their scientific creativity also increased, and there was a significant relationship between scientific process skills and scientific creativity (Baysal, Kaya, & Ucuncu, 2013; Ceran, Gungoren, & Boyacioglu., 2014; Sahin-Pekmez, Aktamis, & Can, 2010; Yang, Lin, Hong, & Lin 2016). The use of the skills gained in science courses in the process of scientific creativity shows that science education is important in developing scientific creativity. Accordingly, it is believed that the importance given by countries to science education will also lead to the development of individuals who can use scientific creativity, and these individuals will play important roles in the development of societies (Hacioglu & Kutru, 2021; İkikat, 2019).

Literature Review and Conceptual Framework

Creativity

It is known that as a term, the first use of creativity dates back to Pluto (Maba, 2019). In his speech to the American Psychology Association in 1950, Guilford described creativity as an option to focus on individual characteristics, motivations, and behaviors, and since then, the conceptualization of creativity has changed (Kurtzberg & Amabile, 2001). Creativity has become a complex concept that affects individuals' lives even when they are not aware of it, and contains certain processes and applications (Barnett, 2019; Robinson, 2008). Creativity has conceptualized the forms of person-centered approaches and context-centered approaches; while the person-centered approaches emphasize more the inner aspects of creative performance, the context-centered approaches focus on the interaction of the individual with the external context in which he/she lives (Sternberg & Lubart, 1992). Differently, the concept of creativity has also been defined as a behavior that each individual can have and can be used in any domain (Koray, 2004).

Torrance (1968) defined creativity as a new product that is introduced to the solution of the problem faced by the individual. Creativity is a skill that exists in every individual and can be found in every aspect of human life, a whole of processes, an attitude, and behavior that covers a vast area from daily life to scientific studies (San,

1979). Dowd (1989), who defined creativity as the process of putting a new product in the middle, did not characterize a non-outcome process as creativity. Creativity is also defined as seeing and combining details (Cellek, 2003). Although there are many definitions of creativity, contrary to conventional and stereotyped ideas, creativity, in general, can be defined as a form of behavior, an ability to produce a new product that is effective in all problem-solving processes, and an ability to take problems from a wide perspective without limiting them (Karakus, 2001; Koray, 2004).

Creativity has been defined as the key to achieving a better standard of living, which makes creativity an important element in education (Robinson, 2008). The fact that creativity is a skill that can be developed through education has also enabled it to be integrated into education systems over the world (Kilic, 2017). In their study, Wyse and Ferrari (2015) determined that the importance of creativity had been included in all 27 European Union countries' national curricula and that politicians and curriculum developers accepted the importance of creativity for education. The development of creativity and creative thinking skills is included in the primary education programs prepared in Turkey as a purpose, strategy, and method (MEB, 2018). In addition, in China, creativity has been integrated into the education system as a skill that has to be gained in education programs since 2001 (Vong, 2008).

Scientific Creativity

Creativity is specific to the domain and includes a scientific background (Mukhopadhyay & Sen, 2013; Sak & Ayas, 2013). Science consists of creative efforts and creativity play an important role in the process of producing scientific information (Hadzigeorgiou, Fokialis, & Kabouropoulou, 2012; Hu & Adey, 2002; Kanli, 2014). If scientific efforts and ideas do not have a specific background and do not create original content, they cannot be considered creative ideas (Huang & Wang, 2019; İnel-Ekici, 2020). Progresses in science and technology are regarded as a significant reflection of creativity (Heller, 2007). Scientific creativity in the 21st century can be shown as a skill that individuals must have to face the problems of the globalized world and produce solutions to these problems (Vries & Lubart, 2017). Therefore, today's education systems have made scientific creativity an important factor in the teaching and learning process (Rasul, Zahriman, Halim, & Roseamnah, 2018). Individuals tend to solve problems that occur in their environment as long as they become interested; therefore, finding and solving scientific problems is unique to scientific creativity (Ayverdi, 2012).

Scientific creativity is an important concept for both individuals and societies, but like creativity, there is no single definition (Demirhan et al., 2018). Scientific creativity has described as "developing theories always requires adding to previous known ones to produce a new product or process" (Denis Celiker, Tokcan, & Korkubilmez, 2015, p.170). Scientific creativity can be defined as the "ability to learn scientific knowledge and solve scientific problems" (Wang & Yu, 2011, p.4179). It is believed that the development of scientific creativity was based on the studies of Hu and Adey (Kilic & Tezel, 2012). In their study, Hu and Adey (2002, p.392) defined scientific creativity as "kind of intellectual trait or ability producing or potentially producing a certain product that is original and has social or personal value, designed with a certain purpose in mind, using given information". They stated that scientific creativity is based on scientific knowledge and skills, and is composed of static structure and

developmental structure. They also proposed "The Scientific Structure Creativity Model (SSCM)" (Hu & Adey, 2002) (See Figure 1).

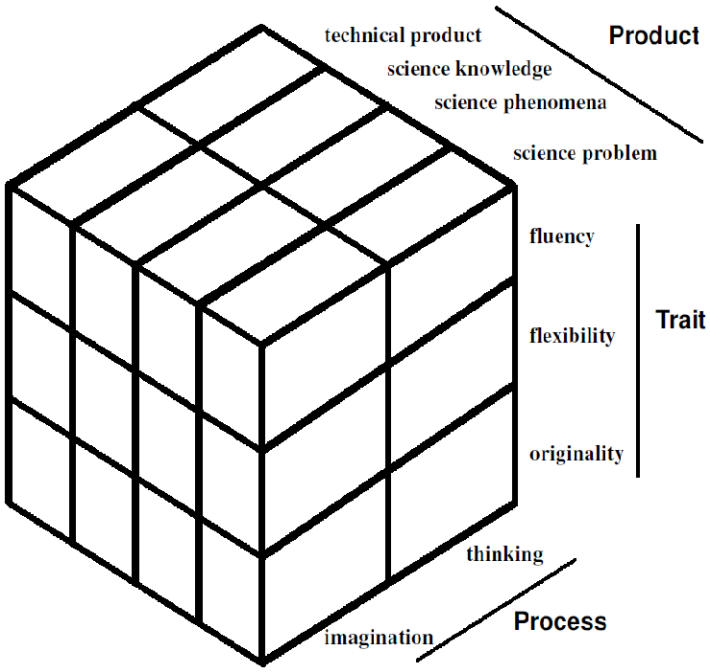

Figure 1. The Scientific Structure Creativity Model (SSCM) (Hu & Adey, 2002)

According to this model, scientific creativity consists of a three-dimensional dynamic structure. Scientific creativity in the model consists of three dimensions: process, trait, and product. The process dimension consists of the sub-dimensions of thinking and dreaming. Hu and Adey (2002) emphasized that scientific creativity is a process and it includes imagination and thinking abilities in the process. The trait dimension includes sub-dimensions of originality, flexibility, and fluency. The scholars emphasized the importance of being fluent, flexible, and original thinking to produce products at the end of the process. The product dimension consists of sub-dimensions of technical product, science knowledge, science phenomena, and scientific problem. The products that will emerge at the end of the scientific creative process should be designed to solve a scientific problem, designed to be a technical product, and associated with scientific knowledge and a scientific phenomenon (Hu & Adey, 2002).

Literature has shown that the contents of the recent studies related to scientific creativity are as follows: impact and relationships of different learning and teaching approaches and activities on scientific creativity (Akcanca & Cerrah Ozsevgec, 2017; Astutik, Susantini, Madlazim, Mohamad, & Supeno, 2020; Dewantara, Mahtari, Nur, Yuanita, & Sunarti, 2020; Karademir, 2016; Kozhevnikov, Kozhevnikov, Yu, & Blazhenkova 2013; Panjaitan & Siagian, 2020; Siew & Ambo, 2020; Wicaksono, 2020; Wulansari, Rusnayati, Saepuzaman, Karim, & Feranie, 2019; Zhao, Zhang, Heng, & Qi, 2021; Zhou, 2021), the effects of STEM and STEAM applications on scientific creativity (Calisici & Benzer, 2021; Genek & Doganca Kucuk, 2020; Rasul et al., 2018; Siew & Ambo, 2020), the effects of different thinking models on scientific creativity and the relationships between them (Demir, 2015; Forthmann, Szardenings, & Dumas, 2020; Vries & Lubart, 2017; Wulansari et al., 2019; Zhu, Shang, Jiang, Pei,

& Su, 2019), perceptions, attitudes, and beliefs related to scientific creativity and the impact of scientific creativity on academic achievement (Calisici & Benzer, 2021; Demirhan & Sahin, 2021; Lee & Park, 2021; Ndeke, Okere, & Keraro, 2016), evaluation of the relationship between problem-solving skills, questioning skills, and scientific process skills, and scientific creativity (Chen, Hu, & Plicher 2016; Panjaitan & Siagian, 2020; Utemov et al., 2020; Yang et al., 2016; Dewantara et al., 2020), effects of science games and toys, animations, and WEB tutorials on scientific creativity (Atesgoz & Sak, 2021; Demir Kacan, 2015; Lupu, Irimia, & Bobric, 2019), and the studies developed by tools to measure scientific creativity and the adaptation of these tools (Aktamis, Pekmez, Can, & Ergin 2005; Bhat & Siddiqui, 2017; Denis Celiker & Balim, 2012; Hu & Adey, 2002; Siew & Lee, 2017).

Since studies on scientific creativity are new, detailed information about these studies is also new (Saptono & Hidayah, 2020). When the literature on scientific creativity was examined, it was seen that there were studies conducted to analyze scientific creativity studies (Boxenbaum, 1991; Stumpf, 1995; Saptono & Hidayah, 2020), but there was no bibliometric analysis in the Google Scholar, ERIC, Scopus, and Web of Science databases.

The accumulated literature records that emerge as a result of increased studies on a particular topic can be summarized using bibliometric methods (Ozkaya, 2019). In bibliometric studies, data resources are international scientific reference indexes. Since these indexes can be accessed via the Web of Science (WoS) or Scopus databases, WoS and Scopus are considered databases that contribute significantly to bibliometric studies (Guz & Rushchitsky, 2009; Guzeller & Celiker, 2017). WoS is a reference database that contains more than 10,000 journals and different information collected from journals, conferences, reports, books, and book series (Aghaei Chadegani et al., 2013). Scopus is a database that contains more than 16,000 journals and more than 4,000 publishers and offers quote-based measurements (Guz & Rushchitsky, 2009). Therefore, the bibliometric analysis of document types such as articles, books, thesis, statements, and reports in the WoS and Scopus databases can be performed using these resources (Sonmez, 2020).

In the current study, the resources in the international reference indexes were used to analyze the studies on scientific creativity. Revealing the scope of the studies of scientific creativity and finding out which studies lead to scientific creativity is the necessity of current research and its main purpose. Based on this purpose, the following research problems were sought in Web of Science and Scopus databases;

1. What are the WoS categories and Scopus categories of the publications scanned using the keyword "scientific creativity"?
2. What are the 10 most cited publications in the scientific creativity studies?
3. Within the scope of published studies on scientific creativity;
    a. Who are the 10 most cited contributors?
    b. Who are the 10 authors with the most studies?
4. Which are the 10 most active journals within the scope of published studies on scientific creativity?
5. Which are the 10 countries with the most publications within the scope of scientific creativity?
6. What are the 10 most active institutions within the scope of published studies on scientific creativity?
7. What are the 10 most common keywords used in scientific creativity studies?

Method

Design

Bibliometric analysis was preferred as a data analysis technique in the current research. Bibliometric is an analysis method that allows statistically visualization of trends specific to the area being investigated in order to obtain information about the activities and specific features of scientific publications (number of studies published every year, multi-studies topics, co-references, journals where studies are published, keywords, countries and institutional co-operation, etc.) (Al, 2008; Al & Costur, 2007; Ciftci et al., 2016; Ozkaya, 2019). Bibliometric analysis is also a method used to provide quantitative analysis of written publications (Ellegaard & Wallin, 2015), improve access to information, and learn more about the structure of the information (Carter-Templeton, Frazier, Wu, & Wyatt, 2018).

Social network analysis is used to determine co-citation relationships in bibliometric analyses (Guzeller & Celiker, 2017). Social network analysis can visualize co-citation networks and identify key actors in the field of research (Karagöz & Yüncü, 2013). In a social network analysis image, the size of the nodes reflects the frequency of the common quote (Van Eck & Waltman, 2014). In the images, nodes that are too close to each other have more frequent quotation rates. The links connecting the two nodes refer to quotations made by other researchers. The closely connected color node sets represent important research themes in the field of research (Hallinger, 2020).

Collection of Data

The scientific documents analyzed in this study were first obtained from the WoS database by scanning with the keyword “scientific creativity”. During the scanning process, the concept of scientific creativity was limited to be in the “title” section of the documents. No restrictions were made in terms of publication years. Bibliometric data of 192 studies from 1975 to 2021 were recorded in the format to be analyzed in the VOSviewer (Version 1.6.17) package program (Van Eck & Waltman, 2010). Secondly, the Scopus database was scanned using the keyword “scientific creativity”. During the scanning process in the Scopus database, the concept of scientific creativity was limited to be in the “title” section of the documents. Bibliometric data of 178 documents from 1975 to 2021 in the Scopus database were recorded in the format that could be processed in the VOSviewer package program. The process of reaching the documents analyzed in the current study was terminated on December 27, 2021.

Findings

In this section, the findings determined as a result of the analysis of the data obtained from the WoS and Scopus databases were compared and integrated in the framework of research problems and presented in visual and table formats.

Categories of Publication in Scientific Creativity Studies

Within the scope of the first sub-problem of the current study, in which categories the studies on scientific

creativity in the WoS and Scopus databases had been conducted was determined. In this context, the determined top-10 categories are presented in Table 1.

Table 1. Top-10 WoS and Scopus Categories of Publications

WoS Database Categories	**N**	**Scopus Database Categories**	**N**
Education/Educational Research	43	Social Sciences	81
Psychology Multidisciplinary	28	Art and Humanities	38
Psychology Educational	19	Psychology	38
History Philosophy of Science	18	Computer Science	20
Philosophy	14	Medicine	10
Multidisciplinary Sciences	12	Engineering	13
Computer Science Interdisciplinary Applications	6	Physics and Astronomy	12
Education Scientific Disciplines	6	Mathematics	9
Engineering Electrical Electronic	6	Business, Management and Accounting	8
Humanities Multidisciplinary	5	Economics, Econometrics and Finance	8

As seen in Table 1, while the scientific creativity studies in the WoS database were mostly included in the "Education/Educational Research" category (N=43), studies on scientific creativity in the Scopus database were mostly included in the "Social Sciences" category (N=81). It was observed that the number of scientific creativity studies in the "Psychology Multidisciplinary" and "Psychology Educational" categories in the WoS database were higher than in other categories. In the Scopus database, it was determined that scientific creativity studies in the categories "Art and Humanities" and "Psychology" were more than in other categories. These results show that scientific creativity studies are generally in the categories of "Education/Education Research" and "Social Sciences". In addition, the fact that scientific creativity studies in the field of psychology rank second in both databases shows that scientific creativity is an interdisciplinary subject. The fewest studies related to scientific creativity in the WoS database were included in the category of "Humanities Multidisciplinary", while the fewest studies in the Scopus database were included in the category of "Economics, Econometrics, and Finance".

Most Cited Studies in Scientific Creativity

As a result of the analyzes conducted within the scope of the second sub-problem of the research, the 10 most cited sources on scientific creativity in the WoS and Scopus databases are presented in Table 2. When Table 2 was examined, it was observed that the article entitled "Scientific creativity as constrained stochastic behavior: The integration of product, person, and process perspectives" published by Simonton (2003) had 367 citations in the WoS database, while it had 438 citations in the Scopus database. Because of the high interest in a study, it can be said that the study is comprehensive in the field of scientific creativity. On the other hand, the study titled "a scientific creativity test for secondary school students" published by Hu and Adey (2002) was the second most cited field article in both the WoS database (129 references) and the Scopus database (159 references), and this shows that it is an effective study on scientific creativity. The researchers who contribute to scientific creativity are discussed in more detail below as a part of the third sub-problem of the research.

Table 2. Top-10 Most Cited Sources for Scientific Creativity Studies

Information of Studies (Wos Database)	Total Citations	Information of Studies (Scopus Database)	Total Citations
Scientific creativity as constrained stochastic behavior: the integration of product, person, and process perspectives. (Simonton, 2003)	367	Scientific creativity as constrained stochastic behavior: The integration of product, person, and process perspectives. (Simonton, 2003)	438
A scientific creativity test for secondary school students. (Hu & Adey, 2002)	129	A scientific creativity test for secondary school students. (Hu & Adey, 2002)	159
Creativity. (Simonton, 2009)	106	Age dynamics in scientific creativity. (Jones & Weinberg, 2011)	100
Age dynamics in scientific creativity. (Jones & Weinberg, 2011)	90	Ability differences among people who have commensurate degrees matter for scientific creativity. (Park, Lubinski & Benbow, 2008)	96
Ability differences among people who have commensurate degrees matter for scientific creativity. (Park, Lubinski & Benbow, 2008)	84	General, artistic and scientific creativity attributes of engineering and music students. (Chartyon & Snelbecker, 2007)	61
The janusian process in scientific creativity. (Rothenberg, 1996)	74	Increasing students' scientific creativity: the “learn to think” ıntervention program. (Hu, Wu, Jia, Yi, Duan, Meyer & Kaufman, 2013)	58
General, artistic and scientific creativity attributes of engineering and music students. (Chartyon & Snelbecker, 2007)	47	The relative influences of domain knowledge and domain-general divergent thinking on scientific creativity and mathematical creativity. (Huang, Peng, Chen, Tseng & Hsu, 2017)	38
Increasing students' scientific creativity: the “learn to think” ıntervention program. (Hu, Wu, Jia, Yi, Duan, Meyer & Kaufman, 2013)	44	The influence of CASE on scientific creativity. (Lin, Hu, Adey & Shen, 2003)	36
Objective measure of scientific creativity: psychometric validity of the creative scientific ability test. (Ayas & Sak, 2014)	32	Objective measure of scientific creativity: psychometric validity of the creative scientific ability test. (Ayas & Sak, 2014)	35
Veblen on scientific creativity: the influence of Charles S. Peirce. (Dyer, 1986)	31	Effectıveness of creative responsibility based teaching (crbt) model on basic physics learning to increase student’s scientific creativity and responsibility. (Suyidno, Nur & Yuanita, 2018)	32

Researchers Contributing to Scientific Creativity Studies

Most Cited Authors in Scientific Creativity Studies

Within the scope of the third sub-problem of the research, the authors who had studied scientific creativity were examined. Firstly, the most cited authors were analyzed. Images obtained from the analysis of WoS and Scopus databases are presented below (see Figure 2 and Figure 3).

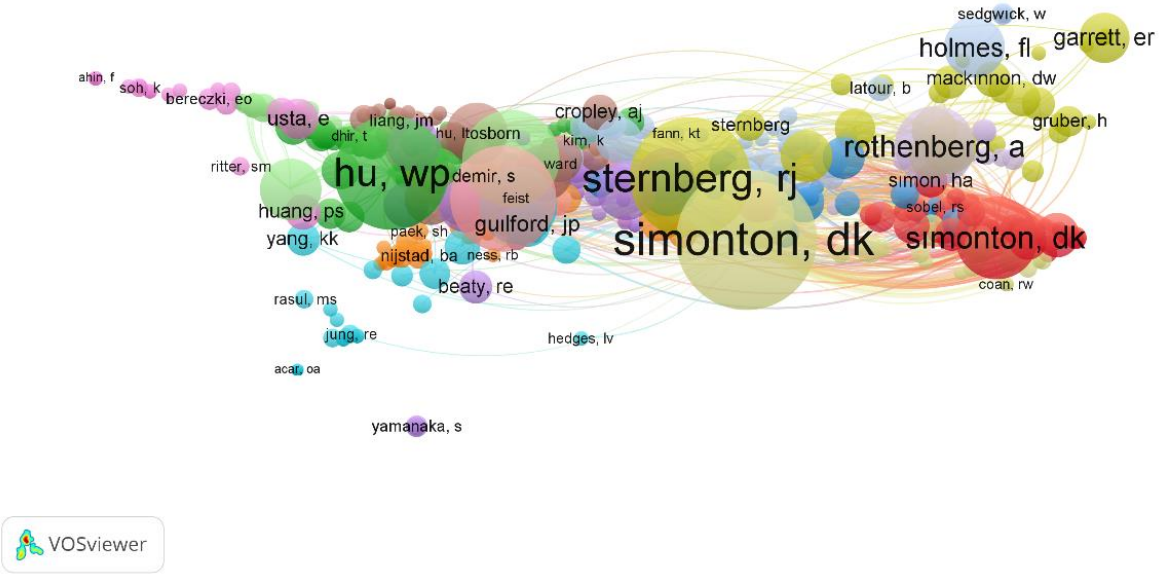

Figure 2. Most Cited Authors in Scientific Creativity Studies in WoS Database

As the size of the nodes in the figure shows, the most co-cited authors in scientific creativity studies in the WoS database are Simonton, D. K., Hu, W., Sternberg, R. J., Runco, M. A., and Torrance, E. P.

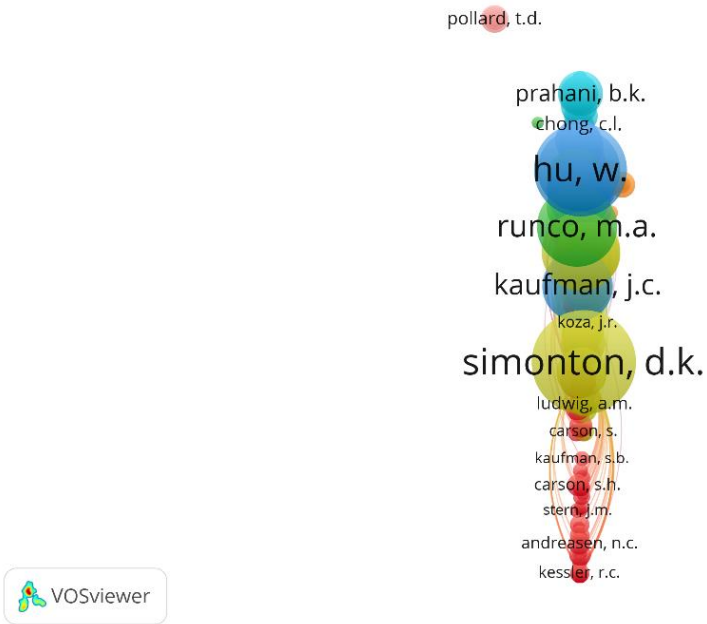

Figure 3. Most Cited Authors in Scientific Creativity Studies in Scopus Database

Analysis conducted based on the size of the nodes showed that the most co-cited authors in the Scopus database were Simonton, D. K., Hu, W., Adey, P., Sternberg, R. J., Runco, M. A., and Kaufman, J. C. The fact that the most cited authors in both databases are joint shows that these authors have done effective studies in scientific creativity field.

Authors with the Most Studies in Scientific Creativity Field

Within the scope of the third sub-problem of the research, secondly, the Top-10 authors who published the most studies on scientific creativity in both databases were analyzed. The authors and number of their studies are shown in Table 3.

Table 3. Top-10 Authors Contributing to the Scientific Creativity Field Most and number of their Publications

Author (WoS Database)	**Number of Study**	**Author (Scopus Database)**	**Number of Study**
Siew, Nyet Moi	5	Siew, Nyet Moi	5
Adey, Philip	3	Hu, Weiping	4
Simonton, Dean Keith	3	Park, Jongwon	4
Suyidno, M. Nur	3	Huang, Chin-Fei	3
Nur, Mohamad	3	Astutik, Sri	3
Sahin, Fatma	3	Lin, Huann-Shyang	3
Park, Jongwon	3	Prahani, Binar Kurnia	3
Huang, Chin-Fei	3	Simonton, Dean Keith	3
Jones, Benjamin F.	2	Holmes, Frederic Lawrence	3
Rothenberg, Albert	2	Adey, Philip	2

When Table 3 was examined, it was seen that N. M. Siew contributed the most to the field with 5 studies registered in both databases. In the WoS database, P. Adey, D. K. Simonton, M. N. Suyidno, M. Nur, F. Sahin, J. Park, and C-H. Huang were found to be the second most influential scientists with 3 published articles. In the Scopus database, on the other hand, W. Hu and J. Park (4 articles each) were determined to be the second-ranked authors contributing to the field. Since most of the scientific creativity studies were conducted more than one author, it was determined that the number of single-author studies is low.

Active Journals in Scientific Creativity Studies

Within the context of the fourth sub-problem of the current study, in which journals the studies on scientific creativity were published in WoS and Scopus databases were determined. In terms of scientific creativity studies, the active journals in the WoS and the Scopus databases are given in Figure 4 and Figure 5.

As seen in Figure 4, it was determined that the journal publishing scientific creativity studies mostly was the

"Journal of Baltic Science Education" in the WoS database. This was followed by "Creativity Research Journal", "Journal of Creative Behavior", "Thinking Skills and Creativity" and "International Journal of Psychology", respectively.

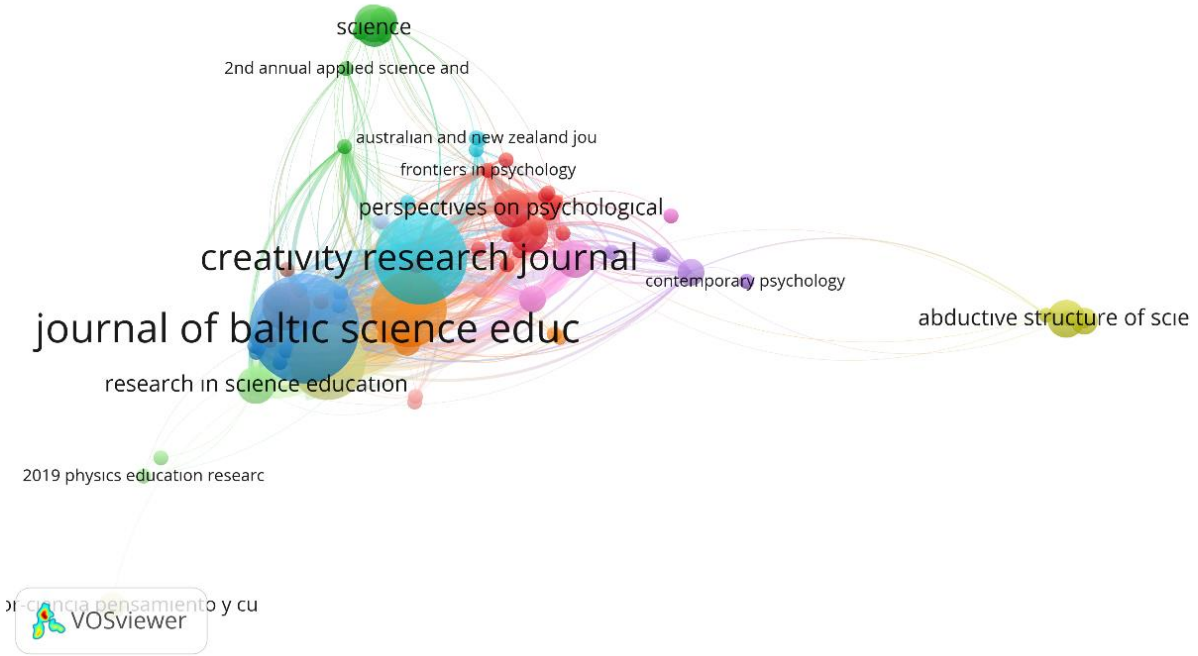

Figure 4. Active Journals Publishing on Scientific Creativity in WoS Database

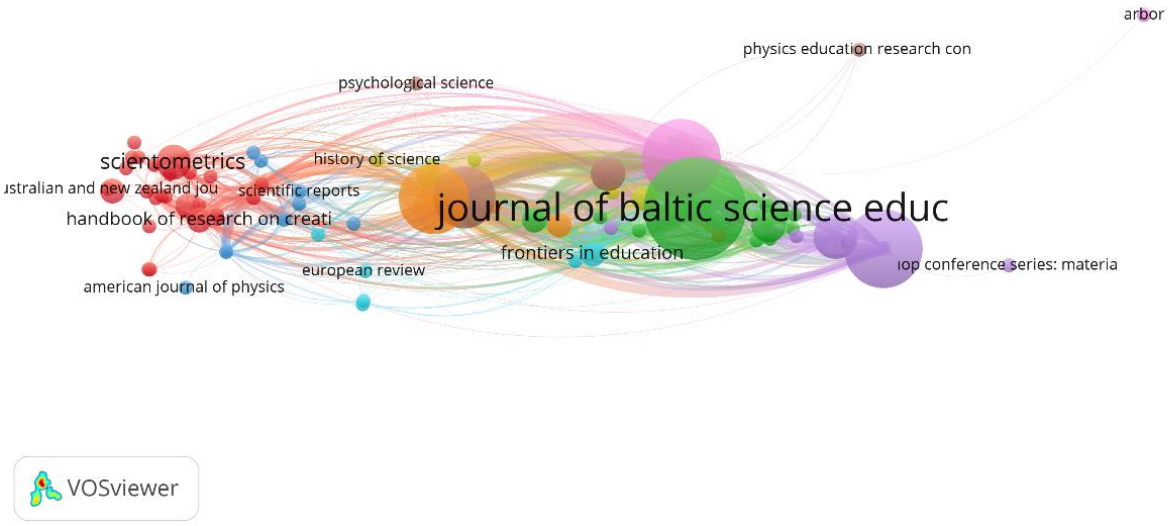

Figure 5. Active Journals Publishing on Scientific Creativity in Scopus Database

Similar to the WoS database, the “Journal of Baltic Science Education” was determined as the journal publishing the most studies on scientific creativity in the Scopus database too. When the sizes of the nodes in the figure were examined, it was seen that in terms of the number of publications, the "Journal of Baltic Science Education" was followed by "Thinking Skills and Creativity", "Journal of Physics: Conference Series", "Creativity Research Journal" and "Journal of Creative Behavior", respectively.

The Top-10 most active journals in terms of publications on scientific creativity in both databases are given in Table 4.

Table 4. Top-10 Most Active Journals in terms of Publications on Scientific Creativity in WoS Database and Scopus Database

Journals of Articles Published (WoS Database)	**N**	**Journals of Articles Published (Scopus Database)**	**N**
Journal of Baltic Science Education	11	Journal of Baltic Science Education	11
Creativity Research Journal	9	Thinking Skills and Creativity	8
Journal of Creative Behavior	7	Journal of Physics: Conference Series	8
Thinking Skills and Creativity	7	Creativity Research Journal	7
International Journal of Psychology	5	Journal of Creative Behavior	6
International Journal of Instruction	4	International Journal of Instruction	4
Perspectives on Psychological Science	3	Research in Science Education	3
Research in Science Education	3	Journal of Turkish Science Education	3
Scientometrics	3	Scientometrics	3
International Journal of Science Education	2	International Journal of Science Education	2

Eight journals (Journal of Baltic Science Education, Creativity Research Journal, Journal of Creative Behavior, Thinking Skills and Creativity, International Journal of Instruction, Research in Science Education, Scientometrics, and International Journal of Science Education) were scanned in both databases. It was determined that these were among the Top-10 journals publishing the most studies in the creativity field. Publication of studies in different journals shows that there are alternatives to the journals in which scientific creativity-related studies can be published and that the studies are not collected in a single journal.

Active Countries in terms of Scientific Creativity Studies

Within the scope of the fifth sub-problem of the research, countries, where scientific creativity studies had been published, were analyzed. Images obtained from the analyses of WoS and Scopus databases are presented below (see Figure 6 and Figure 7). When Figure 6 was examined, it was seen that the most studies on scientific creativity in the WoS database were published in the United States. The figure also shows that the USA is followed by China, Indonesia, Turkey, and Malaysia, respectively.

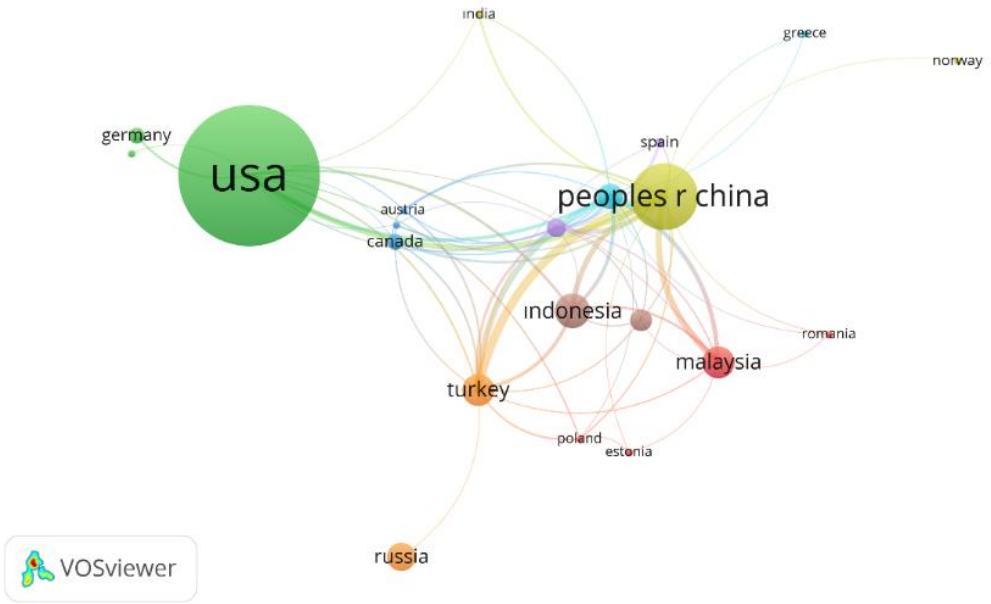

Figure 6. Active Countries in terms of Scientific Creativity Studies in WoS Database

As shown in Figure 7, in the Scopus database, it was seen that the most studies on scientific creativity were published in the United States. It was also determined that the USA was followed by China, Indonesia, Turkey, and the United Kingdom, respectively.

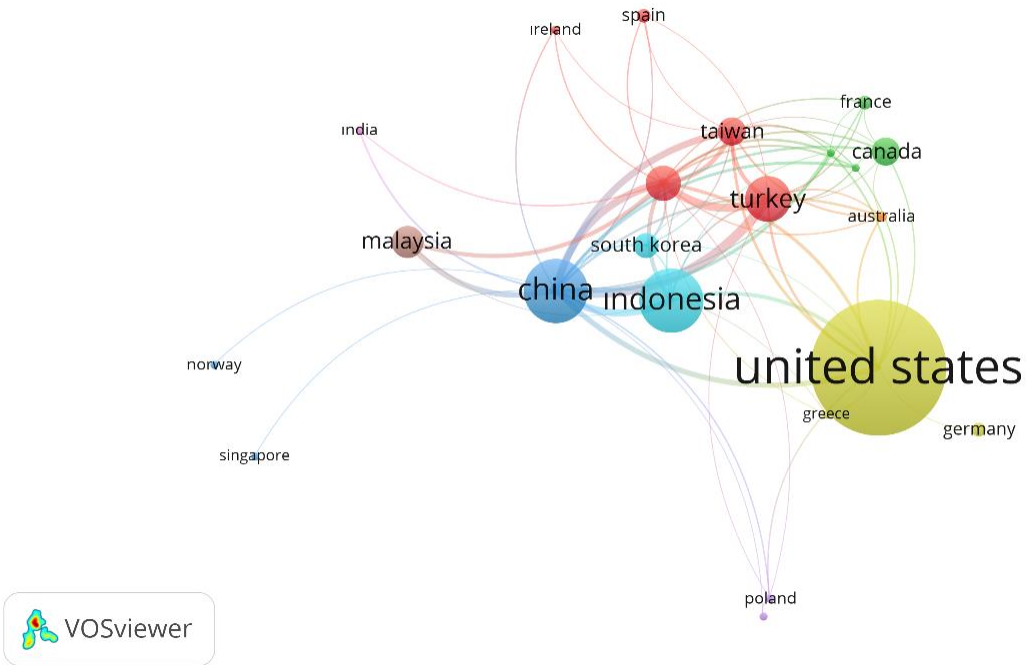

Figure 7. Active Countries in terms of Scientific Creativity Studies in Scopus Database

Table 5 shows the Top-10 countries with the most publications on scientific creativity in the WoS and the Scopus databases and the number of their citations.

Table 5. Countries that have Publications on Scientific Creativity in Wos and Scopus Databases

Country / Region (WoS Database)	N	Citations	Country / Region (Scopus Database)	N	Citations
United States of America	44	917	United States of America	38	942
China	21	267	China	18	341
Indonesia	11	73	Indonesia	18	130
Turkey	10	69	Turkey	13	57
Malaysia	10	34	United Kingdom	10	244
Russian Federation	9	4	Malaysia	9	44
United Kingdom	8	166	Taiwan	8	86
South Korea	7	12	Canada	8	23
Taiwan	6	68	South Korea	7	16
Italy	6	0	Russian Federation	7	0
Canada	5	13	Spain	4	28

When the databases were compared, it was seen that the top 4 countries in both databases (United States of America, China, Indonesia, and Turkey) had the highest number of publications and the highest number of citations in terms of scientific creativity studies. It was observed that articles on scientific creativity published in Italy in the WoS database and in the Russian Federation in the Scopus database received 0 citations.

Active Institutions in terms of Scientific Creativity Studies

Institutions that had publications on scientific creativity were analyzed. Images obtained from the analyses of WoS and Scopus databases are presented in Figure 8 and Figure 9.

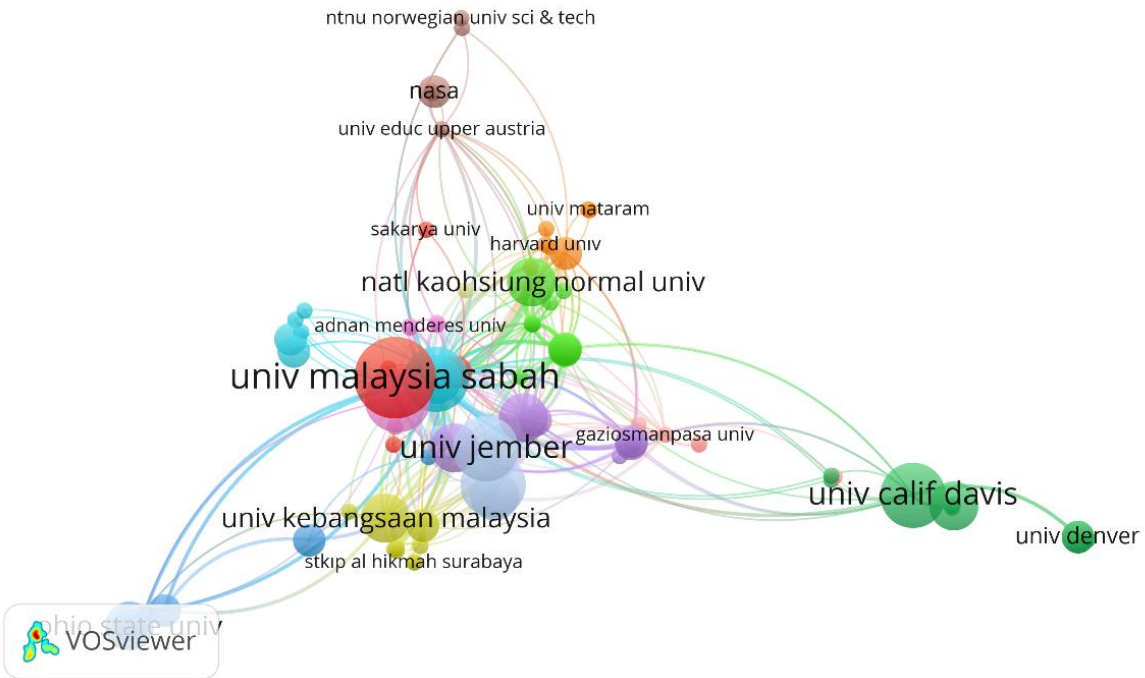

Figure 8. Active Institutions in terms of Scientific Creativity Studies in WoS Database

As seen in Figure 8, it was determined that the institution with the highest number of published studies related to scientific creativity was the University of Malaysia Sabah, and it was followed by California State University and King's College London. The fact that there are more connections and cooperation between the institutions that are active in terms of studies on scientific creativity in the WoS database shows that the work efficiency in this field has increased.

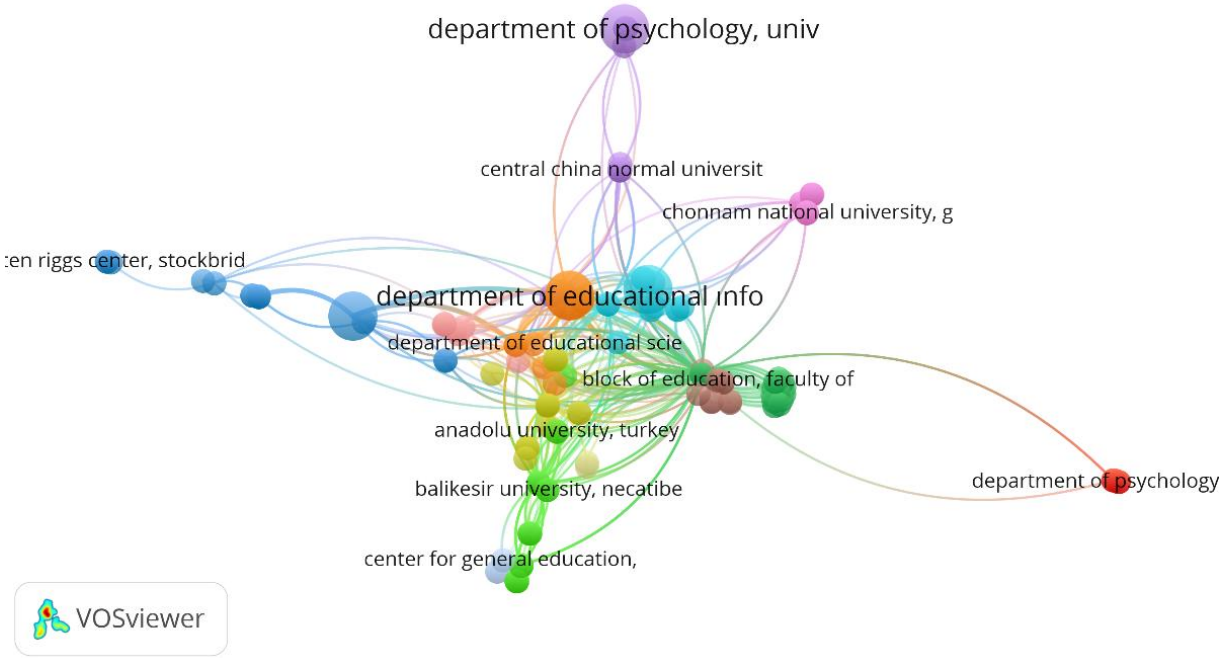

Figure 9. Active Institutions in terms of Scientific Creativity Studies in Scopus Database

Based on Figure 8, it was found that the institution that had the most study on scientific creativity in the Scopus database was the "University of Jember", and it was followed by "East China Normal University", "University of Cambridge", "KTH Royal Institute of Technology", and "Jönköping International Business School", respectively.

Table 6 shows the Top-10 institutions active in scientific creativity studies in both databases, the number of their publications on this issue, and the number of their citations. In Table 6, it is seen that institutions publishing studies on scientific creativity in the WoS and the Scopus databases are mostly different. When the institutions in the WoS database were examined, it was determined that University of Malaysia Sabah had the most publications (N=5) related to scientific creativity, but the number of their citations (citation: 30) was less compared to citations of other institutions.

It was also seen that the highest number of citations belonged to California State University (citation: 485) although it had only 4 publications. Similarly, it was determined that although the numbers of their publications were low, the numbers of citations were high for Shanxi University (N=3; citation:157) and Ohio State University (N=3; citation:137). When the active institutions in terms of scientific creativity studies in the Scopus database were examined, it was also determined that although King's College London and Shanxi University had only 1 publication, the numbers of their citations were higher compared to citations of other institutions.

Table 6. Top-10 Active Institutions in terms of Scientific Creativity Studies

Institutions (WoS Database)	N	Citations	Institutions (Scopus Database)	N	Citations
University of Malaysia Sabah	5	30	University of Jember	2	11
California State University	4	485	East China Normal University	2	11
King's College London	4	159	University of Cambridge	2	2
University of Jember	4	34	KTH Royal Institute of Technology	2	2
Peking University	4	31	Jönköping International Business School	2	28
Surabaya State University	4	19	National Kaohsiung Normal University	2	1
Russian Academy of Sciences	4	0	Kazan Federal University	2	0
Shanxi University	3	157	Western University	2	2
Ohio State University	3	137	King's College London	1	159
Marmara University	3	11	Shanxi University	1	159

Keywords Preferred By Authors in Studies Related to the Scientific Creativity

Related to the seventh sub-problem of the research, the keywords used in studies on scientific creativity were analyzed. The analysis results obtained in this context are given in Figure 10 and Figure 11.

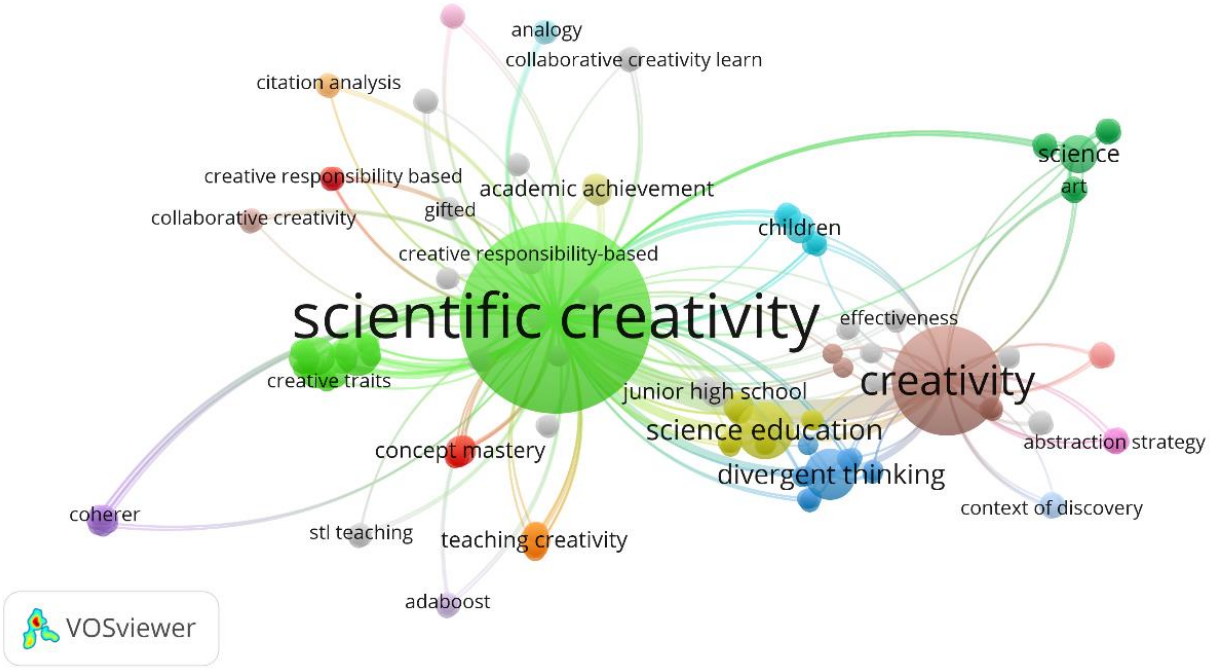

Figure 10. Most Relevant Keywords in WoS Database

When the nodes were examined in Figure 10, it was determined that the most used keywords in the studies in the WoS database were "scientific creativity, creativity, science education, and divergent thinking", respectively.

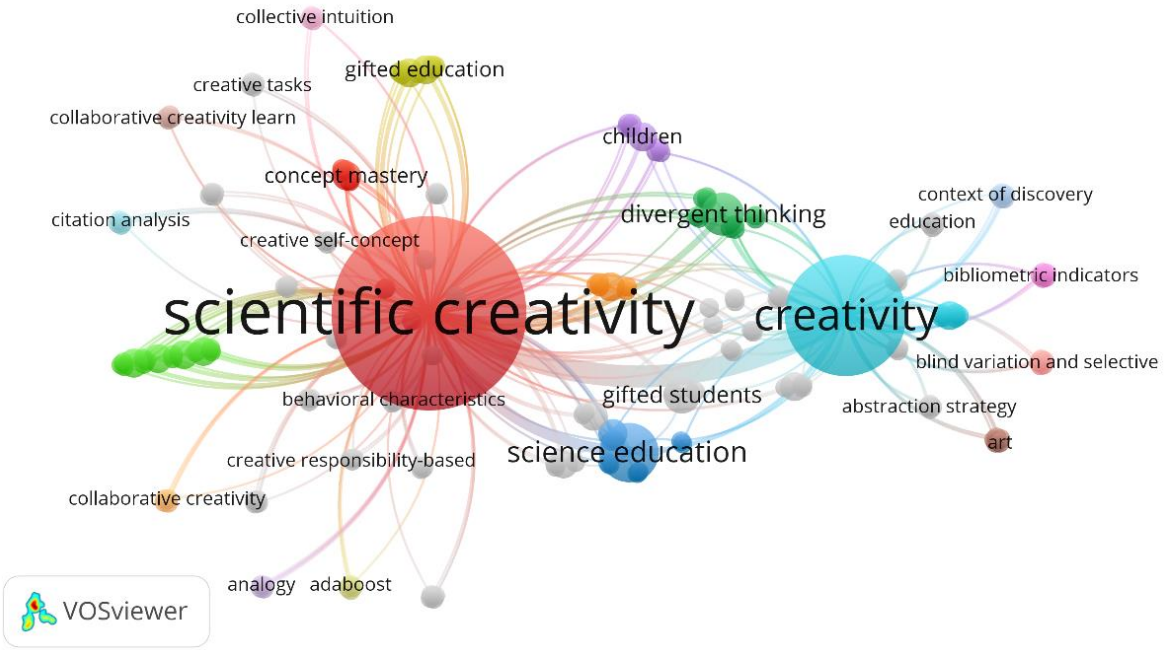

Figure 11. Most Relevant Keywords in Scopus Database

When the nodes in Figure 11 were examined, it was determined that the most used keywords in the studies in the Scopus database were also "scientific creativity, creativity, science education, and divergent thinking", respectively.

The analysis of the Top-10 most used keywords in scientific creativity studies in WoS and Scopus databases is given in Table 7.

Table 7. Top-10 Keywords in Scientific Creativity Studies in WoS and Scopus Databases

Analysis of Top-10 Keywords (WoS Database)	**N**	**Analysis of Top-10 Keywords (Scopus Database)**	**N**
scientific creativity	50	scientific creativity	55
creativity	19	Creativity	24
science education	6	science education	7
divergent thinking	5	divergent thinking	4
stem	4	Gifted students	3
science	3	Children	2
cooperative learning	3	cooperative learning	2
children	2	problem based learning	2
pre-schoolers	2	Effectiveness	2
problem based learning	2	Steam	2

Based on the analysis, it was determined that the words "scientific creativity, creativity, science education, and divergent thinking" were the most used keywords in scientific creativity studies in both databases. It was concluded that the keywords used in studies on scientific creativity were similar in both databases, and the words "cooperative learning, children, and problem-based learning" are among the Top-10 most used keywords.

Discussion and Conclusion

In this research, studies on scientific creativity from 1975 to 2021 in the WoS and Scopus databases were analyzed by using bibliometric analysis. Results of the analysis showed that studies on scientific creativity had been conducted mostly in education/educational research and social science categories. The development of scientific creativity through education (Rasul et al., 2018) and the increase in studies in order for it to be supported by different learning-learning approaches (Astutik et al., 2020; Karademir, 2016; Kozhevnikov et al., 2021) explains why the education/education research and social sciences categories are in the first ranks.

It was found in both databases that the most cited study was "the integration of product, person, and process perspectives" published by Dean Keith Simonton in 2003. The results of the study also showed that Nyet Moi Siew (5 studies) was the author who had the most publications on scientific creativity. It was determined that the most cited authors due to their studies in the field of scientific creativity are "Simonton, D. K., Hu, W., Sternberg, R. J., Runco, M. A., Torrance, E. P., and Kaufman, J. C.". It can be concluded that the most cited authors are active in the scientific creativity field and conduct studies that lead the field. It was also determined that the journal that published the most studies on scientific creativity in both databases was the Journal of Baltic Science Education. In addition, it was revealed that the Creativity Research Journal and Thinking Skills and Creativity journals had substantial studies on scientific creativity. Based on this, it can be concluded that these journals are competent and active journals in the field of scientific creativity. As another result of the research, it was determined that the countries with the most studies on scientific creativity in both databases were the United States of America, China, Indonesia, and Turkey. It was concluded that the number of citations was higher in all four countries depending on the number of studies. It was observed that although the number of studies in United Kingdom was low in both databases, the number of citations was high. Based on this result, it can be said that in the United Kingdom, essential studies in the field of scientific creativity are carried out. The obtained finding is similar to the findings of the study of Saptono & Hidayah (2020) in which different dimensions of scientific creativity studies were analyzed.

The results of the analysis showed that the University of Malaysia Sabah was the institution with the most scientific creativity studies in the WoS database. In the Scopus database, on the other hand, it was determined that the University of Jember had more studies on scientific creativity compared to other institutions. Also, institutions with the highest number of citations were determined as California State University, King's College London, Shanxi University, and Ohio State University, respectively. This finding shows that even though these institutions' number of studies on scientific creativity is low, they carry out effective studies in this field.

In terms of the keywords issue, which was the last sub-problem of the research, it was determined that the words

"scientific creativity, creativity, science education, and divergent thinking" were the most used keywords in scientific creativity studies in both databases.

In this research, studies focusing on scientific creativity and standing out in the WoS and Scopus databases were examined. In this context, the fact that this study only includes publications found in the WoS and Scopus databases can be shown as the most important limitation of it. In terms of future studies, researchers can conduct bibliometric analyzes of scientific creativity by using other existing databases or by incorporating further analysis methods into their research.

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Improving Student Success in Introductory Chemistry using Early Alert and Intervention

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Abstract

Introductory Chemistry is a foundation course that provides students with the basic knowledge and skills to enable them to be successful in the subsequent General Chemistry courses. Despite being an introductory course, it is still challenging for many students, making it ideal for the implementation of various pedagogical initiatives. One such initiative is an Early alert and intervention (EAI) program. Early alert and intervention programs can be described as communication systems which are put in place to help with the timely identification and intervention of students who display attrition risk factors. Data has shown that identifying at risk students early in courses such as Introductory Chemistry and intervening accordingly makes positive impacts on student success. In the fall 2016 semester, pass rates in Introductory Chemistry at one of Miami Dade College's (MDC) campuses saw a sharp decline from that of the collegewide average. An early alert and intervention program was implemented to reverse this decline. This initiative involved the use of a mathematics diagnostic assessment at the beginning of the semester to identify students at risk of failing the course, thus providing the necessary interventions early in the semester. More frequent assessments were also administered throughout the semester to consistently monitor students' progress and provide interventions where necessary. This initiative was conducted over a two-year period and resulted in more than a twenty-percentage point increase in student pass rates for Introductory Chemistry.

Introduction

Student success (retention and progression) is always a main priority for institutions of higher education and much research has been conducted to improve on these metrics. One of the missions of institutions of higher education is to prepare students to be productive members of society. When a student is admitted into an institution, there is a level of commitment on the part of the institution to support the success of the student for the duration of their degree program (Krumrei-Mancuso et al., 2013). Student success is dependent on many variables, some of which are non-academic while others are academic in nature. Some of these variables that are believed to impact student success include; academic potential, normative congruence, intellectual development, grade performance and friendship support (Cele, 2021). It is believed that student success challenges are mainly due to the performance

of first year students as the transition from high school to college requires a keen balance of social, emotional, and academic variables (Cele, 2021). If institutions of higher education are to overcome these attrition risks, programs need to be developed, implemented, and institutionalized that provide first year students the relevant support needed for success.

Many federal programs have invested heavily in post-secondary education making higher education more accessible in the United States. The most significant of which in terms of impact, dates to 1862 with the passage of the Morrill Land-Grant Act which created 76 public institutions being implemented across the country providing educational access to millions of students (Harris, 2022). With educational access no longer restricted to the most successful or affluent, the need for additional student support has now come to light. Miami Dade College (MDC) in Miami Florida, for example is among the largest institutions in the United States by undergraduate enrollment with over 100,000 students enrolled. As majority of these students are Pell Grant eligible, their success outcomes require more intentional support than those of traditional college students. MDC also enrolls more Hispanic undergraduate students than any other college or university (>70%) and it has the third largest black non-Hispanic undergraduate enrollment in the country at 15%. At MDC, more than half of the students are the first in their families to attend college (first generation), 78% of MDC students work while attending college (22% work full time) and 58% are low income (Pell Grant Eligible) with 49% being below the federal poverty level for their household size (Miami Dade College, n.d.).

While earning a college degree is challenging, it is even more so for students who are first generation and Pell eligible. This is a result of the lack of knowledge about higher education from family to be able to support students on their college journey and the lack of financial resources. The lack of financial resources prohibits additional private tutoring or results in additional time being devoted to work versus studying course materials (Nomi, 2004). To combat these non-academic challenges, MDC has instituted numerous programs enabling students to overcome these hurdles. Students are offered financial aid in a variety of forms including grants, scholarships, work-study, and loans. There are also other resources such as a “Single Stop” program that connects students and immediate family members to public benefits and local resources to which they would not otherwise be aware.

Despite this non-academic support from the College, the academic challenges faced by students remain, which fall in the purview of faculty. Depending on the area of study, faculty have implemented various pedagogical strategies to assist students with overcoming barriers that affect learning. General Chemistry for example is a high impact gateway course. Gateway courses can be defined as the first credit-bearing college-level course required to enter in a program of study (Kwak, 2021). General Chemistry is a high impact course because of the high enrollment numbers and a gateway course because it serves as a requirement for most Science, Technology, Engineering and Mathematics (STEM) students. Student retention in STEM courses is an ongoing problem in the United States as a large percentage of students who enroll for a STEM degree either drop out of the institution or change their major by the second year of college if they are not successful in their courses (Gupta & Hartwell, 2019). This is especially true for women and underrepresented minorities (Harris et al., 2020).

General Chemistry is one of the STEM courses that is a barrier to student success (Stone et al., 2018). This is

evident as observed by the General Chemistry national average pass rates only ranging from 50 to 60 percent within the United States (Goodman, 2017). As this course is a barrier to the retention and progression of STEM students, numerous pedagogical initiatives have been utilized nationwide to improve on student success in this course. Some successful initiatives include peer-led team learning, flipped classrooms and other forms of active learning. Peer-led team learning employs previous successful undergraduate students to serve as peer leaders who lead sessions of structured group work (Mitchell et al., 2012, Smith et al., 2014). In a flipped classroom, the traditional lecture is replaced with more active engagement such as iClicker style questions or workshops allowing students to complete most of the instruction outside of the class through a series of short videos, podcasts, or homework assignments (Goodman, 2017). Other instructors have implemented formative assessments in addition to the traditionally used summative assessments. Many chemistry courses utilize summative assessments which is a cumulative assessment implemented at the end of the course of study. Unlike summative assessments, formative assessments evaluate the students' performance throughout the course. Using formative assessments, instructors can interpret students' results, share the results with the students thus allowing them to understand their strengths and weaknesses and provide them an opportunity to reflect on how to improve (Fischer, 2020). Feedback is an important factor that distinguishes formative assessment from summative assessment.

The chosen pedagogical initiative is often dependent on the student population. At MDC, one of the initiatives employed to ensure that students are adequately prepared for General Chemistry was the institutionalization of a placement test. Students' performance on this test, allows them to go directly to the first semester of General Chemistry or to be placed in an Introductory Chemistry course. In recent years, most students have been forgoing the placement test and going directly to Introductory Chemistry resulting in this course now being the high impact gateway course for STEM students at the College. Studies have shown that student retention and persistence is dependent on their success in gateway courses. These courses, however, can act as barriers to student success especially for low-income, first generation, minority, and female students (Kwak, 2021). Gateway courses are important as they provide foundational knowledge that students will need later in their academic careers. Depending on students' intended major, gateway courses will vary.

This article will focus on the challenges faced in an Introductory Chemistry course at one of MDC's campuses and the early alert and intervention initiatives implemented to overcome these challenges allowing for improved student retention and persistence. Early alert and intervention programs are communication systems which are put in place to help with the timely identification and intervention of students who display attrition risk factors (Hanover Research, 2014). Early alert programs are comprised of at least two key components; alerts and intervention (Hanover Research, 2014). The "alerts" are red flags that indicate a problem that needs to be addressed. These red flags usually indicate issues associated with frequent absences, failing grades, behavioral issues amongst other factors. Based on the issue, the next step of the program, the intervention, can then be implemented.

There have been many studies documenting the importance of identifying at risk students and identifying them early enough to make a difference. As a result, ninety three percent of higher education institutions have reported having some form of early alert and intervention programs (Lynch-Holmes et al.) This increased use of early alert

programs can be attributed to factors such as improvements in information technology, the changing demographics of college students and the increased demand for higher eductaion (Marcal, 2019). These programs are often implemented at the institutional level to improve retention and graduation rates (Hanover Research, 2014). Successful early alert programs require the following components; identifying a target population, building an early alert and intervention team, identifying the indicators that will be used to trigger an alert, intervening, measuring, and learning from the impact of these programs. For this study, the early alert and intervention program with its key components was implemented at the course level.

Method

Target Population

Evidence has suggested that early alert programs are most effective when they are designed for specific student populations with a common target population being college freshmen. When a sharp decline in Introductory Chemistry pass rates was observed in the fall of 2016, an early alert and intervention pilot study was conducted in the spring of 2017 to address these declines. This course was an ideal target population as it is comprised predominantly of freshmen students and Introductory Chemistry also serves as a gateway STEM course at MDC.

Two sections of this course taught by the same professor were identified for the early alert and intervention pilot study; one section served as the control group while the other section served as the test group. The traditionally taught class will be referred to as the control group while the early alert and intervention (EAI) class will be referred to as the test group. Each section had an enrollment capacity of 45 students. The control group was taught in a traditional manner consisting of 50-minute lectures three times per week with three assessments administered at five-week intervals and a cumulative assessment at the end of the semester. The test group had similar instructional protocols and assessments as the control group, but modifications were made in the form of additional low stakes assessments to identify weaknesses at the beginning and throughout the course of the semester that could be remediated in a timely manner.

The low stakes assessments included a ten-question mathematics diagnostic test administered during the first week of class. The mathematics diagnostic test was administered at the campus' testing department. Making the assessment computer based allowed for instant feedback while also maintaining the integrity of the assessment. The instant feedback was crucial for the mathematics diagnostic test as this allowed the students who needed mathematics remediation to be identified, contacted, and assisted early in the semester. End of chapter quizzes were also administered approximately every ten days to gauge students' understanding of the material. Performance on these frequent assessments highlighted the shortcomings that students had throughout the course, providing opportunities to remediate these shortcomings in a timely manner through various means of interventions.

Early Alert and Intervention Team

A study conducted by the Garner Institute (Hanover Research, 2014) states that even though academic advisors

and faculty are often most involved in early alert programs, it is common for there to be additional resource personnel in the form of peer staff such as tutors and mentors. To assist the professor with the early alert and intervention pilot study, the test section of the course was assigned a tutor. The assigned tutor was a peer academic leader (PAL).

The PAL was a current MDC STEM student who had excelled in math and chemistry courses. The PAL received an intensive two-day training prior to taking on tutoring assignments as well as additional monthly 30-minute web-based trainings to support academic achievement. An integral part of the training dealt with the Family Educational Rights and Privacy Act (FERPA) to ensure that tutors were knowledgeable about the privacy of students' education records. Training and compensation for the PAL was provided by a Title V STEM grant. The faculty member met weekly with the PAL to provide instructional progress ensuring that the PAL was adequately prepared for tutoring sessions. The PAL also provided the instructor with an update on the tutoring sessions. These updates from the tutor provided the instructor with crucial feedback on concepts that students were struggling with but were not willing to voice in the classroom setting. This has been one of the strengths of this program; coupling the early alert process with peer tutoring interventions.

Identifying Indicators used to Trigger Alerts and Interventions

During the first week of class, students scoring 60% or less on the mathematics diagnostic test or students who did not take the mathematics diagnostic test were identified as at risk of failing the course. The diagnostic test was administered at the campus' testing center using the College's learning management system, Blackboard. This provided the faculty member with immediate results allowing for the identification of students who needed math remediation. At risk students were identified by the faculty member and contacted to schedule an appointment with the PAL during week two of the semester to review the diagnostic test.

Early alert programs typically use various forms of monitoring; within the first few weeks of class, at the midterm or ongoing throughout the semester. This study utilized an ongoing approach. In addition to the mathematics diagnostic test, more frequent assessments in the form of end of chapter quizzes were administered throughout the course of the semester. These quizzes were administered approximately every ten days. Students scoring 60% or less on these end of chapter quizzes were identified as at risk and the necessary interventions provided. These assessments allowed the faculty member to interpret students' performance, provide feedback and recommend interventions. Feedback was in the form of printed personalized progress reports, provided after each assessment. The progress reports notified students of their deficiencies and the need to meet with the PAL that was assigned to the class.

In addition to the printed progress reports, students who were at risk of failing the course were also notified via short messaging service (SMS) - text messages. At the beginning of the semester, students were asked to opt into "Remind" which is a free text messaging mobile application (app) that allows teachers and students to communicate quickly and efficiently. The PAL was also able to communicate directly with the students using this app to make one-on-one tutoring appointments. Using this app proved to be more beneficial than email in

contacting students. Use of this app also ensured that students, who were at risk of failing the class, were never openly identified to their peers. The tutoring sessions provided by the PAL gave students opportunities to work on areas of weaknesses.

Results

Pilot Study Comparing Test Group and Control Group

The implementation of the early alert and intervention pilot resulted in student pass rates in the test group increasing more than twenty percentage points (see Figure 1). The pilot study showed that the test group had a 60% pass rate and 88% retention rate compared to the control group which had a 31% pass rate and 73% retention rate. This increase in pass rates was accomplished by modifying the way in which the course was taught. In addition to tests given at five-week intervals and the cumulative final exam, more frequent assessments in the form of quizzes were administered. The more frequent quizzes provided students additional opportunities to earn points and since these quizzes covered individual chapters, it allowed for ease of learning the material. Feedback for these assessments were provided by the following class period. This prompt feedback allowed for identification of areas of weakness providing the instructor an opportunity to review concepts in a timely manner. As class meeting times are limited, students who earned 60% or lower on these assessments were asked to meet with the tutor for additional review and practice.

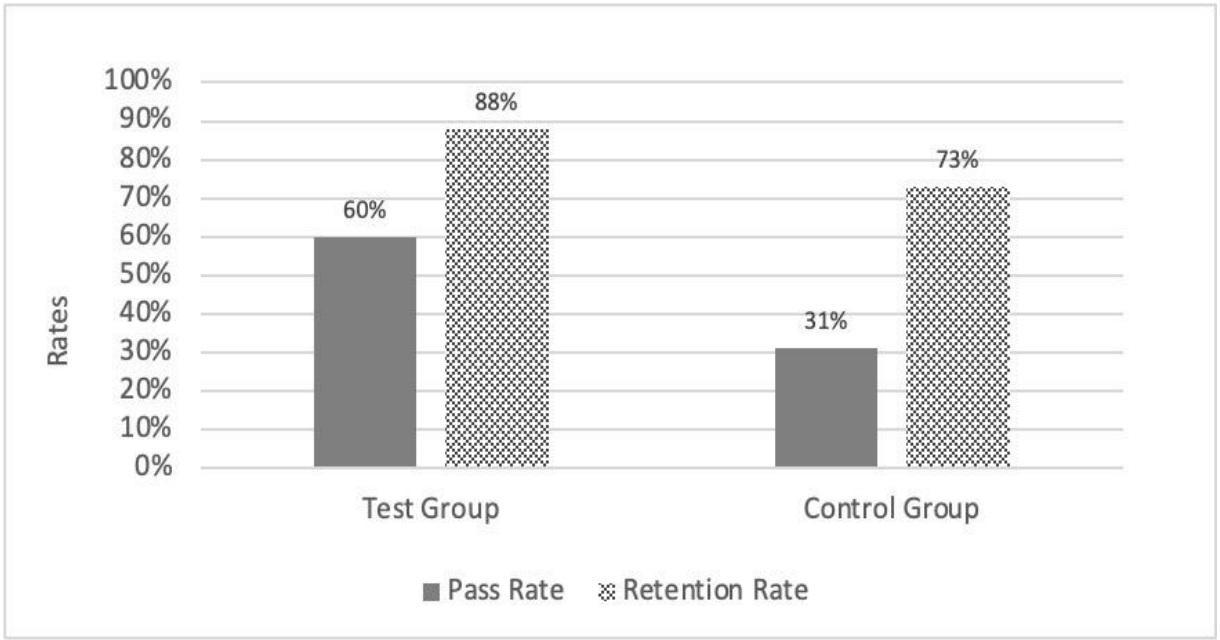

Figure 1. Pass Rates and Retention Rates for Pilot Study

Use of the frequent individual chapter assessments allowed students to be better prepared for the tests that covered multiple chapters. The more frequent assessments were administered approximately every ten days requiring students to study consistently rather than waiting for the night before a test to begin studying as is the typical behavior of first year students. A review of the grade distribution also shows that the test group had more students earning B's and C's and fewer F's and W's when compared to the control group (see Figure 2).

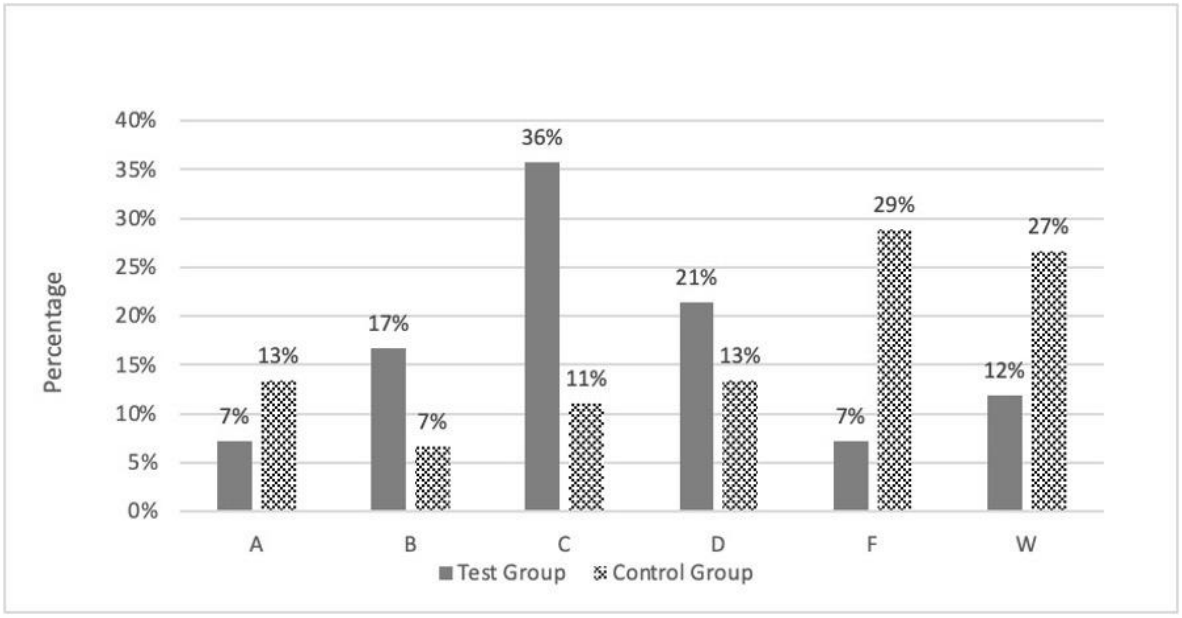

Figure 2. Grade Distribution for Pilot Study

Two-year Study Implementing EAI

The preliminary results obtained from the pilot study resulted in a more long-term study which was conducted to determine if the results could be replicated. The long-term study began in the fall of 2017 and continued through to the fall of 2019. Average pass rates range from 53% to 55% (see Figure 3) which is more than a twenty-percentage point increase when compared to the control group from the spring 2017 pilot study and to classes prior to the pilot study (the pass rates of those classes are not shared in this article but are similar to pass rates of the control group in the pilot study).

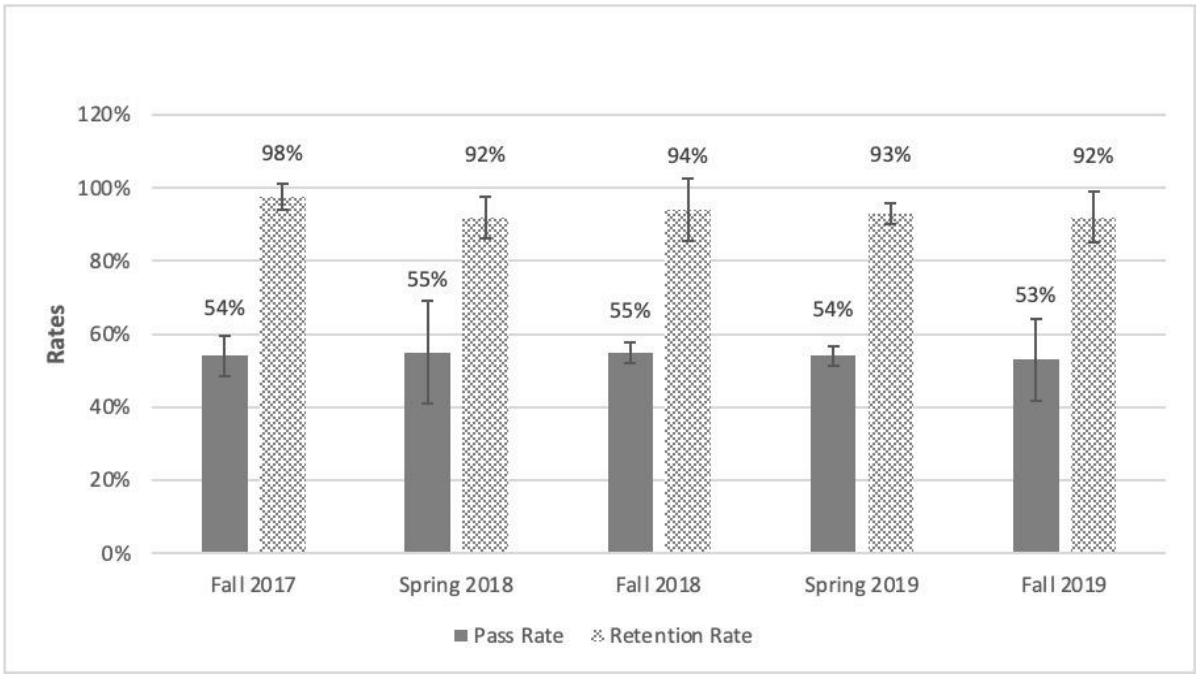

Figure 3. Average Pass Rates and Retention Rates over Two-years

The grade distribution for the two-year study period (see Figure 4) showed the same pattern that was observed in the pilot study; students earned more B's and C's and fewer F's and W's.

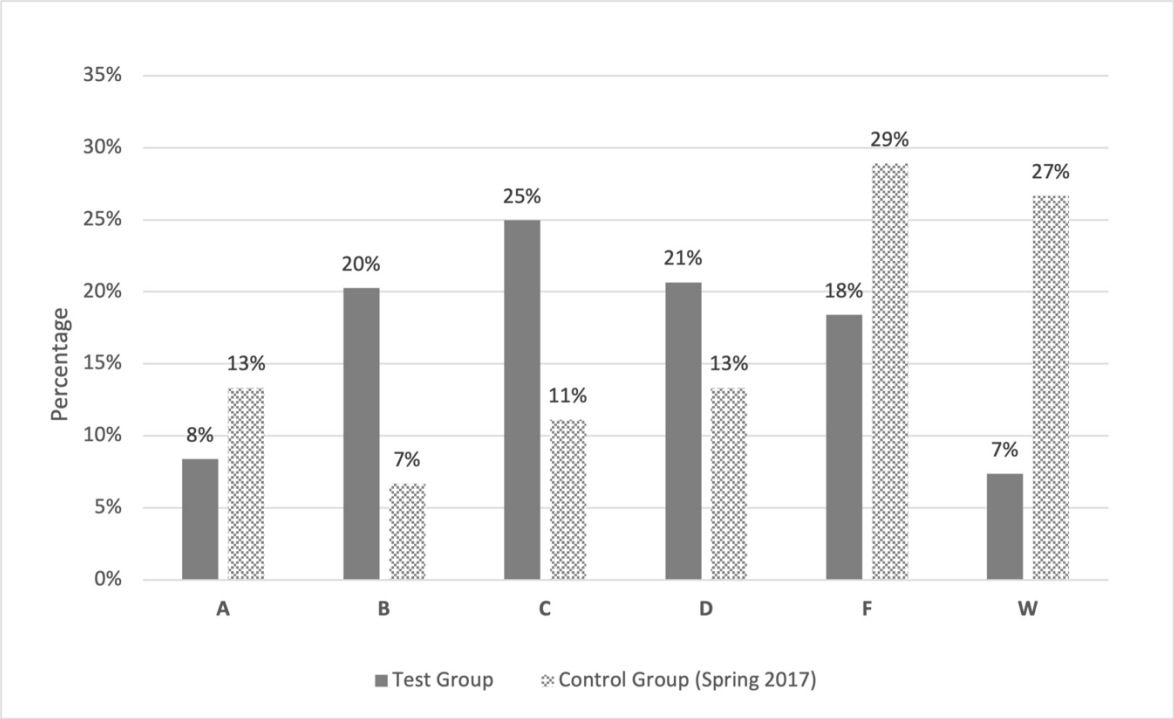

Figure 4. Grade Distribution over Two Years

Discussion

Early alert programs have been an integral part of student retention and success especially at community colleges that have high attrition rates (Dwyer et al., 2018). One way to decrease the attrition risk is to increase academic success. One of the first steps in increasing academic success is to identify at risk students early in the semester and intervene accordingly (Marbouti et al., 2016). Early alert programs may be designed differently across institutions, but they all have a common goal; to identify at risk students and to provide the necessary intervention in a timely manner to improve retention and success rates. Many institutions have been utilizing academic technology systems to support early alert programs. These systems usually allow faculty to flag students who are at risk of failing a course due to a variety of reasons which may include but not limited to numerous absences, poor performance on assessments or lack of engagement in class. Academic advisors receive this data, and the at-risk students will then receive an early alert communication. This early alert communication may be an email or a phone call from an academic advisor who refers the at-risk student to campus support services such as tutoring or mentoring services. Students, however, are not always responsive to emails especially if it is a generic email that is received from an unknown individual. Sometimes, faculty may flag a large number of at-risk students, overwhelming advisors thus diminishing the advisors' ability to resolve all the cases in a timely manner. Faculty eventually receive a case closed notification, but this does not always inform the faculty member of the actions that were taken to assist the student (Marcal, 2019). These are some of the downfalls of early alert programs but there are fixes to these issues. A study which examined how an early alert program promoted student visits to

tutoring centers found evidence which suggests that an early alert system that is focused on personalized feedback positively correlates with the help-seeking behavior of at-risk students in gateway courses (Cai et al., 2014).

The early alert program allowing for personalized feedback to the students that was utilized in this study did not involve the use of a typical institutional implemented academic technology system nor the assistance of advisors at that institution. It was instead conducted at the course level rather than at the institution level. This allowed for personalized feedback to the students in the course because of the consistent and direct communication between the professor, students, and tutors. This personalized feedback to the students was a low cost yet effective approach that may be implemented broadly at any 2- or 4-year institution. Empirical data has shown that identifying at risk students early in a gateway course such as Introductory Chemistry and intervening accordingly could make a big impact on student success. However, implementing early alerts in Introductory Chemistry required modifications to the design of the course. The course was taught in a very traditional manner; three assessments administered at five-week intervals and a cumulative assessment at the end of the semester. However, based on students' performance, this was not the best approach for student success, as a result the course was modified to include an early alert program that was implemented at the course level. This early alert program included more frequent assessments which allowed students to be consistently monitored throughout the semester and provided personalized feedback in a timely manner. Based on the implemented changes and the resulting metrics, the authors attribute the more than 20%-point increase in pass rates observed over the two years to the different strategies used.

Having a strong foundation in mathematics has been reported to be crucial to the success of students in chemistry as many chemistry concepts are dependent on mathematics (Stone et al., 2018). A large number of students taking Introductory Chemistry, struggle with mathematical concepts and so a mandatory mathematics diagnostic test was a part of the course modification. The mathematics diagnostic test was administered during the first week of class allowing mathematics deficiencies to be identified. Being able to identify the mathematical deficiencies early in the semester, means that the students who were at risk of failing because of these deficiencies could be provided with the necessary resources in a timely manner. To provide instant feedback, the mathematics diagnostic test was computer based and administered through the College's testing center. The instant feedback was crucial for the mathematics diagnostic test which allowed the students who needed mathematics remediation to be identified, contacted, and assisted within the first two weeks of classes.

Most students who take Introductory Chemistry are usually in their first year of college and one of the shortcomings that have been identified with this group of students is that they do not work consistently throughout the semester, which usually proves detrimental to their success. In modifying the course, more frequent assessments were implemented in the form of end of chapter quizzes. End of chapter quizzes were administered approximately every ten days. The frequent assessments were beneficial in several ways; students were learning the material in smaller chunks and the frequent assessments resulted in them working consistently throughout the semester rather than studying immediately before a test or an exam. Prior to taking a test or an exam, students were already assessed on these topics and if they did not perform well, remediation was performed making them better equipped for the high stakes tests and exam. The frequent assessments also provided additional

opportunities for students to earn points. Previous studies have noted that providing students frequent feedback have adjusted students' behavior promoting student success in the classroom (Tinto, 2012). The benefit of these frequent assessments was demonstrated by the grade distributions seen in Figure 2 and 4 where students earned more B's and C's and a fewer F's and W's.

Performance on these frequent assessments highlighted the weaknesses that students had and provided opportunities for remediation in a timely manner through various means of interventions. Interventions were in the form of personalized progress reports, provided after each assessment, which notified students of their deficiencies and the need to meet with a tutor that was assigned to the class. These personalized progress reports were distributed during class by the professor. In addition to the personalized progress reports, students who were at risk of failing the course were also notified via text messages to meet with a tutor. Students were very responsive to the text messages as they could schedule individual tutoring sessions via this medium. Having tutors with whom the students were familiar gave them a level of comfort that resulted in them readily attending tutoring sessions. The pilot study showed that students who attended tutoring for more than 10 hours over a three-week period earned an average grade of B. The direct communication from the professor and follow up from the assigned tutors seemed to be more effective than a generic email that is oftentimes sent via an academic technology system when early alert programs are administered at the institution level. The early alert program used in this study resulted in significant gains in pass rates and the authors believe that this was a result of the various strategies that were utilized particularly the implementation of the program at the course level. Maintaining these close interactions between students and faculty was tedious and time consuming but studies have documented that it is these intense close relationships that enhance student learning and intellectual stimulation (Komarraju et al., 2010).

Conclusion

In higher education, student success has many definitions. It can be defined as students' persistence to graduation or completion of learning goals. Regardless of how student success is defined, early engagement and purposeful educational activities are paramount. A sharp decline in student pass rates for Introductory Chemistry, a gateway STEM course, at one of MDC's campuses called for an early engagement and purposeful educational intervention. This was in the form of a pilot study for an early alert and intervention (EAI) program. The pilot study showed promising results which led to the implementation of a long-term study of the early alert and intervention program from the fall of 2017 to the fall of 2019. The increases which were observed in the pass rates can be attributed in part to the inclusion of more frequent assessments. Through these frequent assessments, students at risk of failing the course were identified (alerts) and provided with prompt feedback giving them opportunities to reflect on their weaknesses. In addition to the opportunity to reflect on areas of weaknesses, resources (interventions) were provided to assist students in remediating these weaknesses.

As mentioned above, the gains which were attained through this study were not solely a result of the more frequent assessments but also the use of peer tutors for the interventions. Since students share more openly with their peers, the tutors were made aware of topics of weaknesses which may not have been identified through the quizzes.

Through the weekly meetings with the tutors, the professor was made aware of these topics and intervened accordingly usually through review sessions prior to high stakes tests. Communication played a vital role in improving the pass rates of students in this critical course. Multiple channels for communication were crucial as not all students respond to communications in the same manner. Some students only needed the communication provided on their personalized progress report to act on the instructions while other students needed the additional follow up communication via the remind app (text messages) which allowed for one-on-one communication with the tutors. These one-on-one communications allowed students to arrange tutoring times which were most convenient to them. An important lesson learned throughout this process was the tailoring of the messages being communicated to the students. It was important that these communications were written in a way offering help rather than scolding students for not performing. It was observed that tailoring the language in this way made students more receptive to tutoring.

The combination of an early alert and intervention program with peer tutoring provided much needed improvements in pass rates for Introductory Chemistry. Although this increase is commendable, there is still much work to be done to provide even more gains in this course since Introductory Chemistry is currently one of the STEM gateway courses. The more students who are successful in this course, the greater the success and retention rates will be for the STEM students at the College.

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Pre-service Teachers' Perceptions on the Concept of Oral Communication: A Metaphor Research

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Abstract

This research aims to determine pre-service teachers' mental images of the concept of "Oral Communication" by using the metaphor technique. The qualitative research method was used in the research. The pattern of the study is phenomenology, which is one of the qualitative research method designs. The participants of the research are 84 teacher candidates, 16 male, and 68 female, studying in various departments in the education faculty of a state university in the spring semester of the 2020-2021 academic year. To get the opinions of pre-service teachers as a data collection tool, "Oral Communication… like/similar. Because…" An open-ended question form was used. In this context, pre-service teachers were provided to fill in the blanks in the form using a metaphor. Easily accessible sampling (study group), which is one of the purposive sampling methods, was used in the selection of the sample. The obtained data were analyzed through the content analysis technique. As a result of the analysis of the data obtained from the research, it was determined that the teacher candidates produced a total of 64 metaphors in 6 different categories. These categories, in terms of the metaphors they contain; "Oral Communication as a tool, Oral Communication as an abstract concept, Oral Communication as a basic need, oral communication as an analogy, oral communication as a profession expression, oral communication as the expression of living things" Categorically, it was determined that the density of metaphors was in the category of "oral communication as a tool" and that the pre-service teachers produced metaphors reflecting their generally positive perceptions and thoughts about the concept of oral communication.

Introduction

A human is a social being who feels the need to produce something new in the context he thinks and shares it with others (Cüceloğlu, 1979, p. 308). As social being human feels the need to communicate with other people and therefore realizes their feelings, thoughts, and wishes through language. Language fulfills the function of communication in the realization of all verbal art branches in the transfer of this art (Şendöseyici et al., 2015, p.15). Communication, defined as "transferring feelings, thoughts or interests to others in any imaginable way, transmission, communication" (TDK, 2019, p.1173), is an interactive activity for individuals to get to know themselves and their environment better. The characteristic of the human being as a social being is that he can

transfer what he has learned to the next generations through the interaction in his life. In this respect, communication is a form of expression and agreement for humans, whom we can call the only cultured creature among living things. (Yüksel, 2012, p.4-5). Communication is handled under two headings, verbal and nonverbal. Oral Communication has been the primary communication tool in all areas of communication since the existence of human beings, in short in all areas of life, in terms of sound and language features (Erdönmez, 2019, p. 82). The oldest form of communication in communication, which emerged with the existence of human beings and continues to exist today, is Oral Communication (Çalışır& Uncu, 2018, p.9).

Oral Communication is defined as the verbal transmission and sharing of our feelings, and thoughts to the people in communication (Vural, 2007). Oral Communication is the oral communication of feelings, thoughts, impressions, and designs. Oral Communication, which plays an important role in personal and social relations, has important functions in keeping the language alive and protecting it (Saraç, 2006). "Oral Communication is the type of communication that everyone has to use in every field of social life and their professional life. Since the sender and receiver are in a one-to-one relationship in oral communication, the transfer of feelings, thoughts, and information is healthier. In oral communication, feedback takes place instantly and many feelings and thoughts are conveyed to the other party in a short time. To create a lasting effect in oral communication, it is very important to pay attention to the choice of words, tones, colors, and accents of the voice" (Çalapkulu, 2019). Mankind, trying different ways of communication, has been in a constant search from past to present. This situation paved the way for the emergence of different types of communication. Oral Communication, one of these types of communication, is based on speech activity.

Language is the most important element of Oral Communication. Interactions that take place in daily life are usually through conversation. For this reason, Oral Communication is based on spoken language, which is the basis of social life (Temizyürek, 2007, p.117). Speech, which is an oral communication tool (Gündüz & Şimşek, 2014; Işık, 2013), is the transformation of some thoughts formed in the mind into words through vocal organs (Gündüz & Şimşek, 2014). Speech is accepted as the most basic form of communication (Zeyrek, 2021, p.97). This form of communication, called oral communication or speaking, is the most used but least noticed area in education (Yangın, 2002, p.46). Speech is an activity that directly affects and directs both the private and professional life of a person. The more effective and systematic the speech, also called oral communication, the more success is achieved. The basis of effective communication is the ability to speak well, be intelligible and use the voice effectively. When we look at history, it is seen that historical figures who have shaped humanity have influenced the masses with their effective rhetoric and art of speech and achieved many successes (Kurudayıoğlu, 2003, p.288). Despite scientific and technological developments, Oral Communication skills are one of the most used communication skills in our social life, even though there are negative situations and obstacles. Therefore, oral communication skills can affect the level of communication positively or negatively. To understand and interpret individuals' perceptions of the concept of oral communication, it is necessary to investigate the concept of "oral communication", which is the "basic tool of effective communication", from different perspectives. In this context, metaphors are defined as similes that help to understand the perceptions of individuals. As with many concepts, metaphors can be used to understand individuals' perceptions of the concept of "oral communication".

Metaphors are widely used in everyday relationships. Metaphors that enable complex issues to be understood help individuals communicate effectively and influence others (Thibodeau et al., 2019, p. 1).

Purpose of the Study

This study aims to determine the metaphorical perceptions of pre-service teachers about the concept of "oral communication" through the metaphors they produce. In line with these purposes, answers to the following questions were sought:

1. Which metaphors do pre-service teachers usually use to explain their perceptions of the concept of "oral communication"?
2. Under which conceptual categories were pre-service teachers' metaphors regarding the concept of "oral communication" gathered according to common characteristics?

Oral Communication is one of the basic language skills that allow feelings, thoughts, and wishes to be given based on speech through voice and vocal organs. For this reason, it is aimed to investigate the metaphorical perceptions of pre-service teachers about the concept of oral communication, which is important for them to have effective communication skills, to speak and address in front of the public.

Method

Research Design

This research, which was conducted to determine the metaphors produced by pre-service teachers regarding the concept of "oral communication", is qualitative. The design of the research is the phenomenology design, which is one of the qualitative research method designs. "The phenomenology design allows us to focus on a set of phenomena that we are aware of but do not have a deep, detailed understanding of. The events, experiences, perceptions, orientations, concepts, and situations we encounter in the world we live in appear in different ways in our daily lives. This familiarity does not mean that we understand the facts. Phenomenology provides a suitable research environment to investigate phenomena that are not foreign to us but that we cannot fully comprehend" (Yıldırım & Şimşek, 2008, p.72).

Study Group/Participants

The study group of the research consisted of students in the faculty of education of a university in the spring term of the 2020-2021 academic year Turkish Language and Literature Education, Turkish Education, Guidance and Psychological Counseling, Social Studies Education, Painting Education, Music Education, Geography Education, Philosophy Group Education, Studied in History Education, German Education, French Education, Preschool Education, Science Education, Physical Education, and Sports departments. It consists of 84 teacher candidates, 16 male, and 68 female. Easily accessible sampling, which is one of the purposive sampling methods, was used in the selection of the study group of the research. "This sampling method gives the researcher speed and practicality. Because, in this method, the researcher chooses a situation that is close and easy to reach"

(Yıldırım & Şimşek, 2008, p.113). In this context, pre-service teachers were provided to express their opinions by filling out an online open-ended written question form. The distribution of teacher candidates included in the study according to their branches is shown in Table 1 to ensure the internal validity of the research, the determination of the participants was done voluntarily. Since the participants are kept confidential, in answering the questions PT1: Teacher candidate 1…etc. codes/abbreviations are used.

Table 1. Distribution of Teacher Candidates by the Branches

Department	***f***	***%***
Turkish language and literature education	22	26.1
Guidance and psychological counseling	18	21.4
Social studies education	12	14.2
Pre-school education	6	7.1
Turkish education	5	5.9
Geography education	5	5.9
Painting-business education	4	4.7
Music education	3	3.5
History education	3	3.5
Philosophy group education	2	2.3
German education	1	1.2
French education	1	1.2
Science education	1	1.2
Department of physical education and sports	1	1.2
TOTAL	**84**	**100**

According to Table 1, f=22, 26.1% of the pre-service teachers constituting the study group of the research Turkish Language and Literature Education; f=18, 21.4% Guidance and Psychological Counseling; f=12, 14.2% Social Science Education; f=6/7.1% Pre-School Education; f=5/ 5.9% Turkish Education; Likewise, f=5, 5.9% Geography Education; f=4, 4.7% Art-Painting Education; f=3, 3.5% Music Education; likewise f= 3, 3.5% History Education; f=2/2.3 Philosophy Group; f=1.2% German Language; f=1.2% French Language; f=1.2% Science Education; f=1, 1.2% for Physical Education and Sports Department. The metaphors of the pre-service teachers participating in the research regarding the concept of "Oral communication" and the findings obtained within the scope of the study are given in tables and interpreted. The metaphors of the pre-service teachers regarding the concept of "Oral communication" are shown in the tables as frequency and percentage. It was seen that they produced a total of 64 metaphors, and as a result of the analysis, the metaphors were collected in 6 different conceptual categories and the metaphors were analyzed in tables.

Data Collection Tools

In this study, an online open-ended question form was used as a data collection tool to determine the metaphorical perceptions of pre-service teachers about the concept of Oral communication. In this context, "Oral

communication… is/similar to e/a. Because…" An online open-ended question form was used. Teacher candidates were asked to write the metaphors they created together with their reasons. In the data collection questionnaires prepared online, the "personal information" section was also included for service teachers to indicate their gender and education fields. The data collection link prepared online was voluntarily filled by the participants via Google Forms and their consent was obtained through their e-mail addresses.

The most common types of online data collection used in qualitative research are virtual-focused groups, email and text-based chat rooms, blogs and diaries, and web-based interviews with the help of internet messaging platforms" (Garcia, Standlee, Beckhoof, & Cui, 2009; James and Busher, 2007; Nicholas et al., 2010; cited by Creswell, 2020, p.161). "It has advantages in terms of cost and time efficiency as it reduces the costs of collecting, transporting, and copying data over the internet. It also gives participants the flexibility of time and space, giving them more time to reflect and respond to the information being questioned. Therefore, it can provide an in-depth reflection of the issue under discussion" (Nicholas et al., 2010; cited by Creswell, 2020, p.161).

Analysis of Data

The content analysis technique was used in the analysis of the data obtained from the pre-service teachers with the online questionnaire. "Content analysis is a research tool used to understand many phenomena in different disciplines. The content analysis and descriptive analysis techniques were used together in the evaluation of the data obtained in this study. The main purpose of content analysis is to reach concepts and relationships that can explain the collected data. The data summarized and interpreted in the descriptive analysis are subjected to deeper processing in content analysis, and as a result of this analysis, concepts, and themes that cannot be noticed with a descriptive approach can be discovered. For this purpose, it is necessary to conceptualize the collected data first, then organize it logically according to the emerging concepts and determine the themes that explain the data accordingly. Concepts lead us to themes and through themes, we can organize things better and make them more understandable.

In this framework, we define the data with content analysis and try to reveal the truths that may be hidden in the data. The basic process in content analysis is to collect similar data within the framework of certain concepts and themes, and to organize and interpret them in a way that the reader can understand" (Yıldırım & Şimşek, 2008, p.227-228). The following stages were used in the analysis of the metaphors and their justifications that the participants filled in online via the Google Forms link (Miles & Huberman, 1994):

a) Coding and Inference Stage: The metaphors produced were listed, their reasons were examined, and the answers and explanations that did not answer the question that did not have any justification for the metaphor they expressed were not analyzed.
b) Category Development: Oral communication concept categories were created for the metaphors and justifications of teacher candidates.
c) Ensuring Validity and Reliability: The opinions of academicians who are experts in their fields were consulted and their opinions were taken on the appropriateness of the distribution of metaphors according to categories. Different from the researchers, in the categories created in line with the expert opinion, it

was determined that there were differences of opinion in the five metaphors called "means of expression, a bridge between people, short wall transitions, half of an apple and a part of life" opinions. In this context, Reliability = (consensus/consensus + disagreement) X 100] 64/64+5x100 formula, the percentage of agreement among the coders was calculated as 92%. In qualitative studies, in the evaluations made by experts and researchers, 90% compliance is sufficient in terms of reliability.

d) Category Presentation and Metaphor Distributions: The categories, frequencies, and percentages of the metaphors created for the concept of Oral communication are shown in tables by making them clear and understandable, and some of the answers given by the pre-service teachers to some questions are given in the form of direct quotations. Permission was obtained from the relevant Ethics Committee for the study.

Findings

In this section, the metaphors of the pre-service teachers regarding the concept of "Oral communication" are presented under two main headings. These titles are; the metaphors developed by the pre-service teachers regarding the concept of Oral communication and the metaphor categories developed by the pre-service teachers regarding the concept of "Oral communication" are shown in Table 2.

.

Table 2. Frequency and Percentage of Metaphors Regarding the Concept of Oral Communication

No	**Metaphor**	***f***	***%***	**No**	**Metaphor**	***f***	***%***
1.	Water	4	4.7	33.	The bond between people	1	1.2
2.	Bridge	4	4.7	34.	The world built with language	1	1.2
3.	Mirror	3	3.5	35.	An odorless flower	1	1.2
4.	Life	3	3.5	36.	Writing on water	1	1.2
5.	Oxygen	3	3.5	37.	Two halves of an apple	1	1.2
6.	to breathe	2	2.3	38.	The tea/water that comes to us when we are thirsty in summer	1	1.2
7.	Friendship	2	2.3	39.	A blank page	1	1.2
8.	Sincerity and intimacy	2	2.3	40.	Pouring rain	1	1.2
9.	Easy way to express	2	2.3	41.	Multifaceted phenomenon	1	1.2
10.	Medicine	2	2.3	42.	A means of expression	1	1.2
11.	Pen	2	2.3	43.	Interview	1	1.2
12.	Shopping	2	2.3	44.	Fruit	1	1.2
13.	Key	2	2.3	45.	The light that illuminates the tunnel	1	1.2

No	Metaphor	*f*	%	No	Metaphor	*f*	%
14.	Love	1	1.2	46.	Puzzle	1	1.2
15.	Talking	1	1.2	47.	The Well	1	1.2
16.	Dancing	1	1.2	48.	Machines	1	1.2
17.	Skills	1	1.2	49.	Vehicle	1	1.2
18.	The important part of the picture	1	1.2	50.	Mind	1	1.2
19.	Cat	1	1.2	51.	Bread	1	1.2
20.	Robot	1	1.2	52.	Art	1	1.2
21.	Unwritten communication	1	1.2	53.	Onion in Menemen	1	1.2
22.	Communication tool	1	1.2	54.	Knife	1	1.2
23.	Map	1	1.2	55.	Theatrical stage	1	1.2
24.	Spirit	1	1.2	56.	Growing flowers	1	1.2
25.	Books We Read	1	1.2	57.	Chat	1	1.2
26.	Part of life	1	1.2	58.	Impressive music	1	1.2
27.	Poker face	1	1.2	59.	Sound concept	1	1.2
28.	Truck without brakes	1	1.2	60.	Short wall passes	1	1.2
29.	Chinese torture	1	1.2	61.	Speaking	1	1.2
30.	30. Driving	1	1.2	62.	Electric wire	1	1.2
31.	A ray of light from the dark	1	1.2	63.	Human	1	1.2
32.	Treatment	1	1.2	64.	Stuffed Lemon with Olive Oil	1	1.2
Total						**84**	**100**

When Table 2 is examined, it is seen that a total of 64 metaphors were produced by 84 teacher candidates. These metaphors; water(4), bridge(4), mirror(3), life(3), oxygen(3), breath(2), friendship(2), sincerity and intimacy (2), easy way to express (2), medicine (2), pen(2), shopping(2), key(2), love(1), chat(1), dance(1), skills(1), important part of painting(1), cat(1) , robot(1), unwritten communication(1), communication tool(1), map(1), spirit(1), books we read(1), part of life(1), poker face(1) , popped truck (1), Chinese torture (1), driving (1), a beam of light from the darkness (1), healing (1), the bond between people (1), the world built by language (1), a flower without odor (1) 1), writing on water (1), two halves of an apple (1), tea/water that comes to us when we are thirsty in summer (1), a blank page (1), pouring rain (1), multifaceted phenomenon (1), means of expression(1), interview(1), fruit(1), light that illuminates the tunnel(1), puzzle (1), well (1), machines(1), tool(1), mind(1), bread(1), art (1), onion in menemen dish (1), knife (1), theater stage (1), flower growing (1), conversation (1), impressive music (1), sound (1), short wall passes (1), speech (1), electric wire (1), human (1), stuffed olive oil and lemon (1). Among these metaphors, the metaphors most produced by pre-service teachers are; water(4), bridge(4), mirror(3), life(3), oxygen(3), breath(2), friendship(2), sincerity and intimacy (2), easy way to express (2), medicine (2), pen (2), shopping (2), key (2).

Table 3. Categories, Frequency, and Percentage Distribution of Metaphors Developed for the Concept of "Oral Communication"

Category	**Metaphors**	**Number of Metaphors**	***f***	***%***
Category of Oral Communication as tools and equipment	mirror (3), bridge (4), robot (1), important part of the picture (1), pen (2), map (1), books we read (1), part of life (1), poker face (1), truck with no brakes (1), wrench (2), (1), machines (1), vehicle (1), knife (1), onion in menemen meal (1), theatrical stage (1), electric wire (1), stuffed olive oil and lemon (1), communication tool (1).	20	27	32.1
Oral Communication category as an abstract concept	easy way to express (2), sincerity and intimacy (2), friendship (2), love (1), conversation (1), communication without writing (1), spirit (1), writing on water (1), conversation (1), art (1), impressive music (1), short wall passes (1), half of an apple (1), mind (1), skills (1)	15	18	21.4
Oral Communication category as an analogy	a ray of light from the darkness (1), healing (1), the bond between people (1), the world created by language (1), an odorless flower (1), a blank page (1), pouring rain (1), a multifaceted phenomenon (1), a means of expression (1), the light that illuminates the tunnel (1), the bridge between people (1), the well (1), the concept of sound (1).	13	13	15.4
Oral Communication category as a basic need	life (3), water (4), oxygen (3), breath (2), bread (1), medicine (2), and fruit (1).	7	16	19.0
Oral Communication category as a professional profession	growing flowers (1), dancing (1), shopping (2), driving (1), Chinese torture (1), interviewing (1), and speaking (1)	7	8	9.5
Oral Communication category as the expression of living beings	human (1), cat (1).	2	2	2.3
Total		**64**	**84**	**100**

1. Category of Oral Communication as Tools and Equipment

In this category; there are 27 teacher candidates and 20 metaphors. These metaphors; mirror (3), bridge (4), robot (1), important part of the picture (1), pen (2), map (1), books we read (1), part of life (1), poker face (1) , truck with no brakes (1), wrench (2), machines(1), vehicle(1), knife(1), onion in menemen meal(1), theatrical stage(1), electric wire(1), stuffed olive oil and lemon (1), communication tool (1). The opinions of some pre-service teachers in this category are direct as follows:

PT_3: *"Oral communication is like a 'mirror'. Since people see themselves in the mirror, it is the way of expressing themselves in Oral communication, and therefore there is a connection between the individual who sees himself in the mirror and verbal expression."*

PT_{12}: *"Oral communication is like a robot. Because they listen, understand and apply what they say."*

PT_{18}: *"Oral communication is like the books we read. Because books teach us style and this is a basic need for us."*

PT_{33}: *"Oral communication is key. Because it opens the lock between people and allows the desired emotion and thought to be conveyed."*

PT_{60}: *"Oral communication is like a bridge. Because just as people use the bridge to cross the other side, they also use oral communication to convey their feelings and thoughts to the other side."*

2. Oral Communication Category as an Abstract Concept

There are 18 teacher candidates and 15 metaphors in this category. These metaphors; are "easy way to express (2), sincerity and intimacy (2), friendship (2), love (1), conversation (1), communication without writing (1), spirit (1), writing on water (1), conversation (1), art (1), impressive music (1), short wall passes (1), half of an apple (1), mind (1), skills (1)". The opinions of some pre-service teachers in this category are direct as follows:

PT_2: *"It looks like love. Because we can know love as it is written in books, but we cannot understand it until we experience it."*

PT_6: *"Oral communication is like a way of expressing oneself easily and comfortably. Because the easiest form of communication is oral communication."*

PT_{17}: *"It is like a soul. Because a person who does not communicate verbally is no different from a person who does not have a soul, that is, a lifeless body."*

PT_{52}: *"Oral communication is like friendship. Because being friends with the wrong person can break a heart."*

PT_{62}: *"Oral communication is like mind. Because it is the most basic feature that distinguishes human beings from other beings, and oral communication is a part of it."*

3. Oral Communication Category as an Analogy

In this category; It was determined that 13 teacher candidates and 13 metaphors were produced. These metaphors; a ray of light from the darkness (1), healing (1), the bond between people (1), the world created by language (1),

an odorless flower (1), a blank page (1), pouring rain (1), a multifaceted phenomenon (1), a means of expression (1), the light that illuminates the tunnel (1), the bridge between people (1), the well (1), the concept of sound (1). The opinions of some pre-service teachers in this category are direct as follows:

> **PT_{27}:** *"Oral communication is like walking towards a small beam of light in the dark. Because we are in contact with someone else's self that is separate from ourselves. It is the most important stage of enlightenment."*
>
> **PT_{32}:** *"Oral communication is like a world built with language. Because the building blocks and foundations of the created world are based on language."*
>
> **PT_{47}:** *"It is like a tool that helps people express themselves and express their thoughts by speaking. It is also the easiest form of communication. Because communication is a tool that establishes the bond between people."*
>
> **PT_{57}:** *"Oral communication is a cultural phenomenon, that is, it is like a bridge between people. Because the most effective communication is oral communication."*

4. Oral Communication Category as Basic Need

In this category; It was determined that 7 metaphors were produced by 16 pre-service teachers. These metaphors; are life (3), water (4), oxygen (3), breath (2), bread (1), medicine (2), and fruit (1). The opinions of some pre-service teachers in this category are direct as follows:

> **PT_{15}:** *"Oral Communication is like life. Because the foundation stones necessary for life are similar to the elements that ensure the establishment of healthy oral communication. If any of these cornerstones and elements are removed, we cannot talk about life and healthy oral communication."*
>
> **PT_{29}:** *"Oral communication is a need like oxygen. Because people get along by talking, everything happens by talking, and we wouldn't be able to get along without oral communication."*
>
> **PT_{37}:** *"It is like water. Because one of the basic needs of people is the need to speak."*
>
> **PT_{71}:** *"Oral communication is like medicine. Because, just as medicine heals our body and soul, good oral communication also affects communication, bond, etc. between people develops."*

5. Oral Communication Category as a Professional Profession

In this category; It is seen that 8 pre-service teachers produced 7 metaphors. These metaphors; growing flowers (1), dancing (1), shopping (2), driving (1), Chinese torture (1), interviewing (1), and speaking (1). The opinions of some pre-service teachers in this category are direct as follows:

> **PT_{23}:** *"It looks like Chinese torture because I have a hard time speaking."*
>
> **PT_{48}:** *"Oral communication is like an interview. Because in oral communication, life experience and education level are certain."*
>
> **PT_{69}:** *"Oral communication is like growing flowers. Because in the environment where they interact with each other, what living things want to tell each other and their interactions are mutual. Flowers need water and sun, people need beauty and fragrance. As long as they provide these opportunities to each other, a bond is established between them."*

PT_{79}: *"Oral communication is like chatting. Because we immediately think about a subject, try to grasp it, and start talking."*

6. Oral Communication Category as the Expression of Living Beings

In this category; There are 2 teacher candidates and 2 metaphors. These metaphors; are human (1), and cat (1). The opinions of the pre-service teachers in this category are direct as follows:

PT_{11}: *"Oral communication is like a cat. Because every word we use in oral communication has counter feedback. If we give food to the cat, just as the cat comes again or does not come again when we do not give it, there is feedback in every sentence we make or every word we say in oral communication. Just as we get good feedback when we make good and mature sentences, we also get bad feedback when we use wrong and bad sentences."*

PT_{81}: *"It resembles a human. Because it makes people human."*

Discussion, Conclusion, and Recommendations

This research aims to determine pre-service teachers' perceptions of the concept of "oral communication" based on the use of some mental metaphors regarding the concept of "oral communication" and to explain some emerging metaphors in a systematic and understandable way under certain conceptual frameworks. A total of 64 different metaphors were produced by 84 pre-service teachers participating in this research. When we look at the explanations of the metaphors produced by the pre-service teachers after the conjunction "because" at the root of the problem, it is seen that the metaphors they produce about the subject are generally "positive" in terms of meaning.

Metaphors that can be defined as "negative" by pre-service teachers; They explained this with the metaphors of "Chinese torture, writing on water, empty leaf". It has been determined that the metaphors of "knife, machine, love, an important part of the picture, cat, pouring rain, sound and the well" are produced both positively and negatively in oral communication. The number of positive metaphors (f=53, 82.8%), the number of negative metaphors (f=3, 4.6%), and the number of both positive and negative metaphors (f=8, 12.5%). For the concept of "oral communication", teacher candidates mostly; water (f=4, 4.7%), bridge (4.7%), mirror (3.5%), life (3.5%), oxygen (3.5%), breathing (2%, 3), friendship (2.3%), sincerity and intimacy (2.3%), relaxed expression (2.3%), medicine (2.3%), pens (2.3%), shopping (2.3%), (2.3%) and the total ratio of these metaphors is 38.3%. The number of other metaphors is 51 and the rate of these metaphors is 61.7%.

When the metaphors created by the pre-service teachers regarding the concept of "Oral Communication" are evaluated according to the number of metaphors in the categorical classification, it is the category in which the pre-service teachers produce the most metaphors. It is seen that pre-service teachers produced 20 metaphors in this category and 32.1% of the participants were in this category. In this category, oral communication was tried to be explained by associating it with objects with some functions.

Oral communication in this category; "mirror" reflecting people; "bridge" due to the interconnection function; "part of the picture" in terms of the picture; part of life "part of life"; "truck without brakes" describing the possibility of causing a difficult situation if left unchecked; "key" with unlocking and problem solving; the "poker face", which can take different forms at any moment and have consequences; the "puzzle", which when combined forms a meaningful whole; "tools" with important functions, tools-equipment "machines" that have many functions and make life easier, "knife" with a single face and can be used in different ways; "onion" as material/tool; a "theatrical stage" that reflects life, an "electric wire" that can be considered indispensable for meals and fulfills the function of transmission; the staple food that gives the dish its name, "lemon" as the medium; and "communication tool", which is a basic tool for human beings as a social being, is seen to be explained metaphorically. It is emphasized that there are some aspects that add color, taste and sociability to human life. According to Vatansever Bayraktar (2015), interpersonal communication, which is the basis of relationships, finds its place in all areas of life in mutual interaction. Therefore, the individual, who is a social being, feels the need to communicate in order to "perceive, understand, tell, teach, influence, share and own". A healthy learning-teaching process in the context of educational activities also depends on effective communication.

When we look at the number of metaphors produced by the pre-service teachers participating in the research, it is seen that the category of oral communication as an abstract concept ranks second categorically. It is seen that pre-service teachers produced 15 metaphors in this category and 21.4% of the participants were in this category. Oral communication; has been tried to be explained by associating with some abstract concepts. In this category, Oral Communication, "love" represents extreme love and devotion; "easy way to express" that provides comfortable communication, "speech" that symbolizes mutual communication; unwritten communication "unwritten communication", the "spirit" that reveals the abstract self-concept of human; "writing on water" as it is constantly changing, "sincerity and intimacy" as a sign of being natural and reliable, "friendship" as a supportive and shoulder to shoulder element; "chat" as a sign of friendship, sharing, cooperation and mutual communication; "art" to indicate that it has an aesthetic aspect; "Impressive music" because sound plays an important role and influences people; "short wall pass" representing swap; half of a piece, "half of a piece"; "apple in the sense of thinking, understanding and grasping"; "reason", which symbolizes thinking, understanding and comprehension; Metaphorical perceptions have emerged in the form of "skills" representing mastery and skills. In this category, the concept of oral communication refers to effective thinking and effective communication skills that are not based on writing and require mastery and skill. It is understood that the human being, which includes extreme love and devotion such as abstraction, naturalness, aesthetics, love, is the manifestation of an inseparable and holistic perspective that makes concepts indispensable.

In the study conducted by Çakmak and Aktan (2016), it is the fact that communication techniques should play an important role in the successful implementation of education, and knowing and transferring information are different things. For this reason, it is very important for teachers, who are the basic elements of education, to know communication very well and to consider these issues in the education of students. It has been stated that teachers' speaking style, approach to students, perspective, words and tone of voice, and some other behaviors play an important role in the education of students. It can be said that the oral communication revealed by the pre-service

teachers through the metaphors they produced in the category of "oral communication as an abstract concept" coincides with their views on "communication that requires mastery and dexterity".

It is seen that the metaphors produced by the pre-service teachers participating in the research in the category of "oral communication as a simile expression" ranked third proportionally. It is seen that pre-service teachers produced 13 metaphors in this category and 15.4% of the participants were in this category. Oral communication has been tried to be explained by analogy to some things. Oral communication in this category; "Light beam from the dark" describing the piece of light that illuminates the human, "treatment" denoting the elimination of human discomfort, "connection between people" as a unifying element, and "world built with language" with its shaping function; "flower", which is odorless but with an aesthetic aspect, "empty leaf" denoting a new beginning, "multidimensional phenomenon" resembling cause-effect relationships; means of communication, means of "expression"; means "bridge" in terms of connecting people. In terms of expressing depth, "well" is in the form of "a concept consisting of sound" as the integrity of the strings formed by the combination of sounds. Pre-service teachers use the concept of oral communication as an analogy with its versatile functions among people; It is seen that they explain with elements that connect, illuminate, heal, comfort, direct, and mediate new beginnings. On the other hand, İşcan et al. (2017) in their research titled *"A Study on The Attitudes of Teacher Candidates Towards Verbal Lecture Course and Verbal Lecture",* expressing myself verbally relaxes me." It was determined that 72.3% of the teacher candidates who answered this question gave a positive opinion. According to the results of the research, pre-service teachers stated that they were relieved when they expressed themselves through oral communication. There are similar results with the "relaxing"function of oral communication in the metaphors produced by the pre-service teachers in the category of "oral communication as a simile".

It is seen that the category of "oral communication as a source of basic needs" of the teacher candidates participating in the research ranks fourth proportionally. It is seen that pre-service teachers produced 7 metaphors in this category and 19.0% of the participants were in this category. Oral communication has been tried to be explained by associating it with some basic needs. Oral communication in this category; "life" describes our living, "water" with vital properties, "bread" with vital properties, "oxygen" with vital properties such as water, and "breath", which is also vital and completes the metaphor of "oxygen", "medicine" with problem-solving function. and the "fruit", which provides strength and vitamins to people. It is seen that pre-service teachers explain the concept of oral communication with concepts such as "oxygen, water, bread, and breath" that ensure the continuity of vital functions that are necessary in human life. In addition, it is understood from the metaphors that the concept of Oral Communication emphasizes the therapeutic drug function that gives strength and energy to people. It has been determined that there are studies in the literature that support the results of this research. In the study titled "*University Students' Metaphorical Perception about the Concept of Communication"* by Koç Akran et al., (2018), when the metaphorical perceptions of university students about the concept of "communication" are examined, the concept of "communication" is in the "basic needs" category; It has been determined that they see it as a tool in meeting daily needs and ensuring the continuity of life, and in this context, they produce metaphors such as "bread, water, breath, oxygen". Therefore, it is seen that the metaphors that emerged in this study were produced and similar results emerged with the findings in the category of "Oral Communication as a basic need source".

It is seen that among the metaphors produced categorically by the pre-service teachers participating in the research, "oral communication category as a profession expression" ranks fifth. It is seen that pre-service teachers produced 7 metaphors in this category and 9.5% of the participants were in this category. Oral communication has been tried to be explained according to various professions. In this category, oral communication concepts are "growing flowers", which requires fine craftsmanship and precision, "dancing", which refers to a profession performed in different ways, "shopping" as an activity, "driving a car" as doing a job. "Chinese torture" denotes hard work, "interview", which expresses meeting, interview, and meeting, is "conversation", which expresses mutual conversation. Pre-service teachers explained the concept of oral communication as a difficult profession that requires the expression of the profession, competence, and skill together. Pre-service teachers also defined Oral Communication as a process of establishing a dialogue based on sincerity and intimacy, in which delicacy and sensitivity are at the forefront. As a matter of fact, as Toruç (2019, pp.5-6) said, oral communication can be considered as an action that pushes people more than written communication and causes excitement. For this reason, oral communication is the form of communication that students have the most difficulty in communicating with their immediate environment. In oral communication, problems are encountered in many subjects such as making sense, distinguishing sounds, and having sufficient vocabulary, grammar, attention, and concentration. The development of oral communication skills is accepted as an important indicator for the rise of the individual as a career, gaining prestige and reputation. It is seen that the "oral communication category as the expression of living beings" of the pre-service teachers participating in the research is in the last place proportionally among the metaphors. It is seen that pre-service teachers produced 2 metaphors in this category and 2.3% of the participants were in this category. Oral communication has been tried to be explained by associating it with some living beings. In this category, pre-service teachers define the concept of oral communication; explaining with the metaphor of "human" and "cat" in terms of communication. With these metaphors obtained from the research, it was emphasized that communication is indispensable for living things, contains positive or negative feedback, and is based on interaction.

In the context of the results obtained from this study, the following suggestions were put forward:

- This research reveals how pre-service teachers perceive the concept of "Oral Communication", which has important functions in human communication. The metaphors that emerged in this context can provide important data on the "non-communication problem" based on the lack of oral communication that has emerged in parallel with some studies to be made on oral communication skills and scientific and technological developments in our age.
- This research, which is conducted at the higher education level and for teacher candidates, can be carried out in different ways at primary and secondary education levels.
- Based on this study, in which the concept of oral communication is investigated, metaphorical research can be conducted to raise awareness about the concept of written communication.

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Sámi Early Childhood Education and Sustainability in the Arctic

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Abstract

The Sámi are indigenous people living in Finland, Norway, Sweden, and Russia. There are about 10,500 Sámi in Finland. The traditional settlement area of the Sámi is located in the Arctic. Endangered Inari, Skolt, and Northern Sámi languages are spoken in Finland, and efforts are made to implement the traditions, principles, and values of indigenous culture. The traditional settlement area of the indigenous Sámi people is in the Arctic. The Sámi culture and languages are in a vulnerable position due to their present climate change. Early childhood education (ECE) is of particular value to contribute to the preservation and strengthening of indigenous culture and, consequently, to sustainable development in the Arctic. The purpose of this article is to describe Arctic sustainable Sámi early childhood education based on the perceptions and experiences of Sámi early childhood educators in Finland. The research shows that cultural sustainability was approached by using Sámi language in activities, supporting children's Sámi identity, using materials and items important in culture, and having a tight connection with Sámi community.

Introduction

The Sámi are indigenous people living in Finland, Norway, Sweden, and Russia. There are about 10,500 Sámi in Finland. The traditional settlement area of the Sámi is located in the Arctic. Endangered Inari, Skolt, and Northern Sámi languages are spoken in Finland, and efforts are made to implement the traditions, principles, and values of indigenous culture. The Sámi, as the only indigenous people of the European Union, are in a particularly vulnerable position due to the present climate change (Määttä, Hyvärinen, Äärelä & Uusiautti 2020; Jaakkola, Juntunen & Näkkäläjärvi 2018; Näkkäläjärvi, Juntunen & Jaakkola 2020). As the country of residence of the Sámi people, Finland belongs to the Arctic, the polar region located in the northernmost part of the Earth. Today, the living conditions, traditions, and culture of the Arctic are particularly vulnerable in a technically and economically rapidly changing globalizing world where the economy is moving at an accelerating pace from natural industries to modern technology (McGhee 2005).

Early childhood education (ECE) is of particular value, as it can contribute to the preservation and strengthening of indigenous culture and, consequently, to sustainable development in the Arctic. Early education for Sámi children has two folded tasks. On one side, it can socialize with the majority culture and society and, on the other side it can implement enculturation, i.e., conscious, and purposeful education in Sámi culture (Kim Park 2007). According to research, indigenous families also consider enculturation to their local culture a priority (see Ritchie

2017). Early childhood education can be implemented as sustainable education to ensure the continuity of the Sámi cultural heritage and the intergenerational transmission in the Arctic (Laine 2016; Laiti 2018). At the same time, it is also a question about supporting sustainable development in the Arctic (Määttä, Hyvärinen, Äärelä & Uusiautti 2020).

This article describes the implementation of Sámi early childhood education as told by Sámi early childhood educators. The aim is to highlight the voice of professional educators on how sustainable development and Sámi culture in the Arctic can be promoted by strengthening Sámi early childhood education. Early childhood educators are culture transferees and mentors of sustainability education for children in the sensitivity phase of early childhood education. Children can continue to preserve and strengthen Sámi culture and adopt the foundations of eco-social civilization in the Arctic (Salonen & Åhlberg 2011).

Sámi Early Childhood Education

In Finland, all ECE is organized according to the National Core Curriculum for Early Childhood Education (Finnish National Agency for Education 2018). Based on the document, every Sámi child has a right to have support in the development of their cultural identity. Children whose mother tongue is Sámi are entitled to early education in Sámi throughout Finland. Sámi early childhood education is also guided by the Sámi Early Childhood Education Plan (The Sámi Parliament 2009) and the Manual of Daily Practices (The Sámi Parliament 2013). These documents can be used in the planning and implementation of Sámi early childhood education at the local level (Laiti 2018).

Sámi early childhood education is implemented at the crossroads of two cultures. It promotes the adoption of both the Finnish majority culture and the Sámi indigenous culture. The coexistence and forms of early childhood education when involving two cultures have been studied to some extent (Kitson & Bowes 2010; Preston, Cottler, Pelletier & Pearce 2011; Tonyan 2015). One, major culture, the base has been considered too narrow and inflexible (Kitson & Bowes 2010, 82). In everyday life, local diversity should be considered (Tobin 2005) and indigenous culture should not be left as an "ingredient" (Năone & Au 2010, 150).

Nature and Sustainable Development in the Arctic

The traditional way to look at sustainable development is to focus on social, economic, environmental, and institutional indicators of development. (Määttä & Uusiautti 2020; Purvis, Mao & Robinson 2019). Still, sustainable development (SD) is multidimensional, complex, and intertwined in nature (Gershenson & Heylighen 2005). According to Salonen and Åhlberg (2011) in a sustainable society, all human activities are in accordance with the principles of SD. The flowing three components are in focus simultaneously: 1) economy, 2) ecosystems, and 3) human beings, communities, and society. Transitioning into an ecologically, economically, and socially sustainable society requires innovative solutions, new policies, and behavioral change (Salonen & Åhlberg 2011). In the Arctic, in particular, the rapid environmental and economic development poses a threat to nature and traditional welfare, identities, and cultures of indigenous Sámi people (Näkkäläjärvi, Juntunen & Jaakkola 2020).

The way of life and culture of the people of the Arctic is based on a strong coexistence with nature and respect for nature. In Sámi thinking, nature is more than the physical environment, the variations of the seasons, animals, or plants. Indigenous peoples see nature as an important context for action, growth, and learning (Lee-Hammond 2017; Rowan 2017). In the Arctic, nature as an environment and nature-related livelihoods is the starting point for the Sámi way of life and culture (Balto 2008, 57; Jannok Nutti & Kuoljok 2014; Markkula & Helander-Renvall 2014; Sara & Mathiesen 2020). Sámi culture is considered to have developed over the centuries in close interaction and coexistence with nature (Jannok Nutti 2008, 201). Immediate life in nature has meant that the relationship with nature has become an essential part of Sámi identity.

Over time, traditional knowledge about nature, its properties, and man's ability to survive in nature has accumulated. Traditional knowledge refers to knowledge that enables people to take advantage of a sustainable daily nature according to their everyday needs (Sara & Mathiesen 2020). Markkula and Helander-Renvall (2014, 6) use the term "traditional ecological knowledge" (TEK) for cumulative, intergenerational knowledge, skills, practices, and beliefs (Casi, Guttorm & Virtanen 2021). It is commonly understood that 'traditional' does not refer to something only from the past (Battiste & Youngblood Henderson 2012, 46); rather, it is about wisdom acquired on a long-term scale, constantly changing and being updated (Berkes 2012, 5).

TEK thus binds together generations of the past, the present, and the future (Porsanger & Guttorm 2011, 18). TEK is not simply a descriptive body of literature, and nor can it be categorized into separate fields, such as biology, geography, or chemistry. It is holistic, a 'way of life, a relationship that requires doing' (McGregor 2004, 396), and practical experience (Porsanger & Guttorm 2011, 18). Thus, Indigenous peoples view the environment, people, and knowledge inseparably and interconnected with each other (McGregor 2004, 394–95). TEK also forms a significant part of Indigenous communities' cultural heritage (Porsanger & Virtanen 2019, 293). TEK is still needed in current living environments and institutions.

In this article, we talk about Sámi’s early childhood education from the perspective of cultural sustainability. The purpose of this article is to describe Arctic sustainable Sámi early childhood education (= ASSECE) based on the perceptions and experiences of Sámi early childhood educators in Finland. The purpose is to describe the goals and implementation of Sámi early childhood education as told by Sámi early childhood educators.

Method

To describe the educational sustainability of Sámi early childhood education the following research question has been asked for the study:

> How do Sámi early childhood educators describe the Arctic sustainable Sámi early childhood education? What kind of focal points does Sámi indigenous culture produce into practice? How is Arctic sustainability conveyed to children based on the narration of early childhood educators in Sámi early childhood education?

The research informants offer a representative take on the employees in Sámi early childhood education. At the moment of conducting the research, Finland employed forty-four (44) Sámi early childhood educators (Lehtola 2015). They were all invited to participate in our interview. In the end, interviews were conducted with 23 early childhood educators, who came from all over Finland. They represented all Sámi language groups and worked in versatile early childhood education positions, including teachers, nursery workers, and private childminders.

The interviews were conducted as free-form individual interviews in which the implementation of Sámi early childhood education was discussed (Laiti 2018). The informants shared their thoughts on, experiences with, and conceptions of their daily work as Sámi with the Sámi culture and education. The interviews were conducted in the spring and autumn of 2016. The themes of the interviews concerned the daily routines of Sámi early childhood education. The educators were encouraged to share the goals they set concerning Sámi early childhood education, the principles and starting points that guide their work and the elements that they consider when planning, implementing and evaluating early childhood education.

The material was subjected to a qualitative content analysis that focused on topics related to the research question. The routines of early childhood education are typically framed as brief episodes or depictions of actions that the educators found natural to describe. The descriptions of daily routines were based on specific themes instead of following a plotline (Hsieh & Shannon 2005).

The analysis consisted of three phases (Graneheim & Lundman 2004). In the reduction phase, the material was simplified, and irrelevant information was removed. In the second phase, the material was clustered or grouped into subcategories according to topical or thematic similarities. In the third phase, the subcategories were reorganized and transposed to content-based thematic categories (Mayring 2004) that represented the central outcomes of the study. We prioritized presenting the material in a concise and succinct form, focusing primarily on the retention of essential information (Graneheim & Lundman 2004).

Lastly, a note should be made about the researchers' positions considering this study. The first author lives in a Sámi family and speaks Northern Sámi. She has a long working history in various roles in both Sámi and majority culture early childhood education. James Banks (2006, 180) dubs such a position 'the external-insider'. The term refers to a researcher who has grown up in another culture, but through the reflection of her own experiences and values can understand the community she studies and supports its objectives. The second author has studied and developed Sámi pedagogical tools (see Keskitalo & Määttä 2011; Keskitalo, Määttä & Uusiautti 2011, 2012a, 2012b, 2013; Keskitalo, Uusiautti & Määttä 2012).

Results

The analysis resulted in two main lines of stories. On the other hand, educators narrated the goals of their daily work and on the other, they talked about the contents and methods they use to deliver the Sámi culture. The sections below the results of these.

Goals of Arctic Sustainable Sámi Early Childhood Education

Teachers of Sámi early childhood education considered the general goals of children's social, mental, and physical development important. Similarly, the safety and well-being of children in the Arctic were seen as the basis for all work. In addition, the most important goals were

1) supporting and passing on the Sámi language from one generation to another,
2) maintaining and strengthening the child's Sámi cultural connection, and
3) strengthening the Sámi identity, and
4) the importance of cooperation.

Supporting the Sámi Language

Educators in Sámi early childhood education saw the revival, transmission, and preservation of the Sámi language as the main goal. There was a desire to articulate the Sámi language in all kindergarten interactions. Educators said that *"…language issue is the most important thing"*. They considered it important to practice the language in different everyday situations in kindergarten while supporting the child's mental, social, cognitive, and motor development.

The goals of language learning were set according to the child's language skills to create favourable conditions for children to use the language. Not all children participating in ASSECE actively used the Sámi language. In this case, it was seen as important to activate their passive language skills so that they would become active in using the language at school and later in their lives. Educators described this as follows:

> *"- - so that children would be left with the desire to keep their language ... and that it would be good and safe for children to be here"*

The aim was to create motivation to learn and revitalize and to use and develop the Sámi language so that children would also appreciate and be proud of the Sámi language.

Positive Attitude towards Sámi Culture

Early childhood educators considered it important to make Sámi culture visible and known in a way that is suitable for children, articulating in the child's world of experience. Thus, the aim was to provide concrete information as well as contact with activities and industries belonging to the Sámi culture. The participation of children in Sámi-language events and active actions were considered important, as the goal was to pass on the culture from one generation to the next. The aim was to create a positive and encouraging image of Sámi culture as well as traditional livelihoods. An early childhood educator stated how important it was to

> *"maintain and promote culture. In addition, to maintain a certain connection with the Sámi way of life. So that it would not disappear, and at no point would it be paused."*

In order to internalize Sámi culture, early childhood educators saw it as a key goal to make children appreciate the connection with nature, living in nature, and respecting nature. The nature connection is based on an annual cycle of eight seasons. Sámi life has always been connected to the cycle of nature. The relationship between man and nature and respect for nature are central to the Sámi tradition. (The Sámi Parliament 2013, 15). Traditional livelihoods are tied to nature. The preservation of traditional livelihoods supports the sustainable development of the Arctic and the preservation of Sámi culture.

Strengthening Sámi Identity

In addition to linguistic and cultural goals, early childhood educators paid attention to the goal of strengthening the Sámi identity of children. Central to this is identification with the Sámi, notification of the Sámi culture, and associating oneself with it. Early childhood educators considered the development of the Sámi identity to be a demanding goal that requires time and continuous work (see also Sarivaara, Määttä & Uusiautti 2013).

In Sámi children's identity support have to pay attention to the fact that they live under the influence of two cultures. Finnish major culture is visible and hearable everywhere whereas Sámi language, materials, worldview are rare to experience and many times invisible. In situation like this the rooting of Sámi culture needs special attention (Laiti & Määttä 2022a). For some children with a Sámi background, Sámi is a new thing and identification with it was considered as an important goal so that children get to know and value their Sámi ethnicity.

> *"...that they can tell for themselves that we are Sámi and are really proud of it. And they also think it's fun because they like to tell about their own backgrounds."*

The goals of early childhood educators support James Banks's (2006) theory of the development of cultural identity. Therefore, it is important that children learn to accept the positive and negative views associated with their own culture. They learn to be proud of their background and culture in a healthy way. The goal of early childhood educators was to develop a clear cultural identity for children and for them to learn to function fluently in two different cultures (Banks 2006).

Early childhood educators expressed the view that to develop a person's identity, it is important to provide a learning and operating environment that supports a positive Sámi identity and allows for everyday activities and choices that strengthen the child's awareness and appreciation of their Sámi heritage (see Hall & Fenelon 2015).

The Importance of Cooperation

Sámi early childhood educators felt it was important that ECEC staff had a common vision of the goals. The goals could be adhered to when the staff had a common direction and practices. Sámi was a strong unifying factor. It also involved respecting other employees and striving to make working together. As one informant said:

"that everyone gets to say their own thought and influence their work".

Cooperation with the parents of the children and the whole Sámi community was also considered important and was sought to be valued in various ways. In the Sámi community, intergenerational interaction acts as a mediator of traditional knowledge. Therefore, children's families and relatives were considered active actors in kindergartens. They could arrange some activities for the group, *"One's parent arranged an ice fishing trip for us"*. Parents and grandparents were perceived as educational partners and were encouraged to visit ECEC, participate in activities, plan different cultural tasks, and build learning environments.

The aim was also to support the upbringing task of parents and help with their insecurities within the two cultures, as well as to increase their mutual communication. Early childhood educators try different ways to highlight the importance of children's families and kinship while supporting the Sámi identity of children.

Contents and Methods of Arctic Sustainable Sámi Early Childhood Education

Sámi culture was made visible in everyday activities and interaction situations by speaking and storytelling, music, reading, crafts, and other actions. Early childhood educators were well aware that storytelling has a special role in transferring Sámi culture and tradition and strengthening identity (Author 2018; Authors 2022; Jannok Nutti & Kuoljok 2014; Kuokkanen 2008; Nergård 2005; Äärelä 2016).

Nature

Early childhood educators strive to develop children's relationship with nature as an important part of Sámi culture. Fostering a connection with nature was a pervasive theme throughout early childhood education. This result is consistent with results obtained among other indigenous peoples (e.g., Alcock & Ritchie 2018).

"Watching nature all year round is one important thing"

Nature was explored by observing the environment together and drawing children's attention to natural phenomena by talking to them about them (including seasonal variations). Knowing the characteristics of plants and animals was a part of developing the relationship between children and nature.

"---... my Sámi is in that relationship with my nature. That it is so evident in it ... that respect for nature ... and that you can learn in nature. "

Sámi early childhood educators valued nature as a wide range of activities and considered it important to go out in nature and the forest and do things outdoors. Roaming around the forest brought nature close. The Sámi perception of nature or the "forest" has previously been examined by e.g. Guttorm, Kantonen, Kramvig, & Pyhälä (2021) and Joks, Østmo and Law (2020).

One early childhood educator summed up the thoughts of those working in early Sámi early childhood education on the relationship between forest, language, and culture, saying, *"the language and culture are in the woods."* For Sámi woods is not only a physical environment, but it is also a state of mind (Joks, Østmo & Law 2020). The early childhood educator described the activities in the forest as natural and diverse. We go to the forest often; it is a remarkable place. Outdoor activities were more than one part of the day's program, it's part of the culture.

> *"We went berry-picking again today. Tomorrow we will bake blueberry muffins… we go to the forest to pick berries or, like, just to take a walk in the forest. Children sit around on the hummocks… and… eat the berries they find… We go look for where could there be a fox's den… and what could be a bear's lair and… and all these kinds of things… children really do love to wander around in nature."*

In Sámi culture, the seasonal activity according to the traditional Sámi way of life is called the eight-season cycle (The Sámi Parliament 2009, 2013). The annual planning of activities was based on the Sámi annual cycle of the seasons. Reindeer work, the acquisition and processing of various materials and ingredients, berry picking, and fishing follow a certain annual cycle. Early childhood educators said they choose the content themes for educational and teaching situations according to the cycle of nature. Autumn topics include fall colors, migratory birds in the spring, and frosts in the winter. A significant part of the Arctic midwinter year cycle is the end of the period of polar night and the emergence of the sun.

> *"[Themes] come to us pretty much from the culture and the seasonal activities or… phenomena, so we have covered the northern lights and the rising of the sun, or the re-emergence of the sun --."*

By following the movements of the sun, the children developed a sense of time and an understanding of the rhythm of the day.

> *"Then we follow the sun with the children… meaning that we have a specific spot where we go and sit on a rock… and watch… so then, when the sun has sunk below a certain group of trees, it is 11 o'clock and it is time for us to eat."*

Early childhood educators noted how the environment can be viewed *"through the eyes of culture,"* to see it as Sámi. For example, the topics of spring and summer were the birth of calves and their ear markings. Similarly, scheduling willow grouse hunting at the right time in the winter is the theme of Sámi early childhood education.

> *"Now lately we have done, for instance… the trapping of the willow grouse… we will do the bear now over the spring, when the bear wakes up, and then later, we will cover the calf, the reindeer calf. It is usually some animal or a culturally relevant activity, so for that week we then plan one arts and crafts work that is connected to that topic, and then we do it."*

Nature was considered to be the most important source of Arctic sustainable Sámi early childhood education. Sámi culture is deeply rooted in the Arctic nature and the livelihood connected with it.

Authenticity

Early childhood educators recounted how authentic materials and ingredients were used in Sámi early childhood education, if possible, at all. They also said they strive to use the right tools. The importance of authentic activity in education has been emphasized by Nergård (2005), among others, and it supports the task defined for early Sámi early childhood education to develop and establish a child's relationship with culture (The Sámi Parliament 2013). Early childhood educators prefer natural materials, recycled materials, or traditional cultural materials. The interview material found examples of how twigs are used to build play shelters or potatoes to make trolls. These materials were retrieved from the forest itself or the surrounding area.

> *"We have those theme weeks when we deal with handiwork in more detail. For example, now we have this going on, that we have worked with leather… the children got to feel and smell the material and then we have done those… of course, it is difficult to knit or sew such leather. We then cut a small leather bag like that, which we glued on cardboard, and then that we decorated it with baize and beads."*

In the stories of early childhood educators, one form of authentic making and experiencing was getting to know traditional foods and handling them. For example, reindeer jerky was made in the spring, and fishing was practiced in many ways:

> *"Then sometimes we have prepared air-dried meat…Well, by doing it ourselves of course, who might have a special interest in fishing… In autumn we fished with a net… in winter we went ice-fishing… then we took the snowmobile to go… on ice-fishing trips. The ice-fishing trip was a part of this house… yes, they have done that for quite a long time already. So this is how you see the difference, that… the environment is used a lot."*

Early childhood educators believe that the duodji belongs to the Sámi culture. It refers to Sámi handicrafts, the holistic process of producing handicrafts, and the finished work itself (Guttorm 2012). Early childhood educators told how the children got involved with real materials, got to follow and experiment with shoe hay processing, wool carding, or making leather for fur shoes, for example.

Towards Sámi Language Skills

As a method of teaching the language, early childhood educators said that they use the Sámi language in all their activities and thus show its importance. They explicate situations, talk a lot and show the possibilities offered by the language as well as its richness. They aim to increase and recall the vocabulary of the Sámi language (see Keskitalo, Määttä & Uusiautti 2014).

> *"Really you have to talk and talk all day ... all the time ... this is not the job of a quiet person ..."*

The Sámi language was also used in the games. Early childhood educators designed a variety of games and

activities to develop language skills. Narration, fairy tales, and plays promoted the use of the Sámi language. Efforts were also made to promote children's desire to speak the Sámi language in free-form games.

> *"Many times when a child says something in Finnish, we pretend we don't understand, and then the child has the necessity to try even a few words in Sámi, and then we are helped. Or if the child says something in Finnish, then we say it in Sámi."*

Attention was paid to enriching the child's Sámi language and expanding their vocabulary, for example by displaying written vocabularies during activities. Similarly, Sámi-language posters, signs, and bulletins on windows, walls, and in the hallway were displayed to children as a Sámi language landscape (Linkola 2014). The language landscape aimed to remind and strengthen the position of the Sámi language in relation to the majority language and the child's courage to speak Sámi.

Early childhood educators were also careful not to be too strict and demanding in practicing the language. The use of language was supposed to feel comfortable and unifying with the children.

> *"Trying to help when a child doesn't know all the words at the dinner table, for example. Avoid saying 'Speak Sámi, properly' so as not to thrust upon"*

Overall, early childhood educators make a very deliberate effort to support the learning of the Sámi language and its use in interaction and as a means of communication. The Sámi language was spoken in various everyday activities, such as bringing the child to day-care or picking them up, dressing and undressing, and tidying up. Eating, sleeping, and outdoor activities were also the daily situations in which Sámi was spoken (see also Äärelä 2016). Yet, early childhood educators did not take language learning and the transition to new generations for granted. Their daily work was the constant use of the Sámi language as well as conscious work to preserve the language. In this implementation, children were considered both as a group and especially on a personal level in various encounters (Sarivaara, Uusiautti & Määttä 2013; Pasanen 2015, 44).

Discussion

Life in the Arctic is intertwined with nature, the natural cycle, the forests, water bodies, and the knowledge and understanding of animal and plant species and their connection with human life. This has demanded that one has had to learn to cope with the changing natural situations and find the best solutions. The attitude of coping has become a Sámi way of facing and resolving various life situations. Survival involves the idea of adapting human activities to local ecology, the situation, and the sustainability of nature. Succeeding requires faith in survival, skills to perform, and knowledge of the conditions and laws of the current situation (Balto 2005; Laiti 2018; Uusiautti 2016). In the Sámi world view, nature is not isolated from the culture and society of the region but they are seen as a whole system (Nicol 2014).

This study shows that the nature – human -connection as seen in Sámi community, has its influences even in the

implementation of Sámi early childhood education. Particularly, it has influenced the ways how children's everyday life learning and the support for development are organized (Aikio 2010; Balto 2008; Bjøru & Solbakken 2021). This is the most important way how the Actic sustainainability was conveyed to children.

Asta Balto (2008, 57) divides the cultural values of Sámi education into five main entities: "oktavuohta lundui" (connection to nature), "iešbirgejupmi" (survival), "ieśráđálašvuohta" (self-sufficiency),"gierdevašvuohta" (patience), and "friddjavuohta" (freedom). These are the vocal points of Sámi education. Aimo Aikio (2010) describes the Sámi attitude towards life with the term "birgema" (see also Boine & Saus 2012; Bjøru & Solbakken 2021). These were reflected in the goals for Sámi's early childhood education as well as in the contents of it and the methods used.

Sámi early educators' main goals for Sámi early childhood education were learning the language, supporting children's Sámi language learning, supporting children's identity formation, positive attitude towards Sámi culture and language, and cooperation with Sámi community. These were implemented and connected with the help of Sámi contents connected with nature, authentic livelihoods, or traditional handcraft, and using Sámi language. Nature was deemed the most valuable basis and resource of activity, and on the other hand children's identity formation was supported by emphasizing the connection to nature and usage of Sámi language.

Sámi early childhood education has the opportunity to contribute to the vitality of Sámi languages and cultures which can lead to sustainable development in the Arctic. A strong majority of cultural routines and policies challenge the cultural customs of the Sámi indigenous people and the sustainability of the Arctic's operational environment. The understanding of time or ecological setting is one example of this. For the Sámi the time is cyclic when the majority culture understands time as linear. (Keskitalo 2010; Markkula & Relander-Renvall 2014); Lehtola & Ruotsala 2017). Adults engaged in early childhood education are required to adapt and coordinate educational activities to preserve and strengthen the cultural customs and lifestyles of the Arctic in the institutional context (Laiti & Määttä 2022b).

What adults do with children and how they operate in everyday environments are essential for cultural continuity and sustainable development in the Arctic. The content and form of everyday activities depend on the interpretations of adults working with children. What they consider to be essential is what they consider to be culturally appropriate and meaningful goals and objectives. Adults who work with children decide how and why children's daily lives are organized as they are.

Although the activities are regulated and guided by different regulations and norms, professionals still have the power to decide on everyday pedagogical solutions and with them on the pedagogical environments of early childhood (Määttä & Uusiautti 2014). Employees of Sámi early childhood education are actors who create meaning and actively adapt their daily activities to preserve their own Sámi culture in the Arctic. They are key players in sustainable development and education. The story told by early childhood educators is not only their personal story but also a story about how to contribute to the sustainable development of the Arctic and the preservation and development of perspectives and worldviews provided by indigenous culture. (Martin 2017).

Conclusion

In this study, we have focused on the implementation of Arctic sustainable Sámi early childhood education. Sámi culture is founded on traditional values that express respect for nature, and the activities constructed based on these values are implemented in Sámi early childhood education. Nature is at the core of Sámi culture: it is where the culture was born. Nature is considered to provide the framework for a good life, and facilitating a good life is a central value of culturally relevant development in the Arctic.

The results of the study show how early childhood educators act as agents of the Sámi culture. They occupy a crucial position in the pursuit to teach future generations to adopt the values, the world view, and practices of the Sámi culture. Flexibility and integrated activities that are adjusted to the local circumstances are significant matters of early childhood education in the protection of the culture's survival. The results point out that teachers and assistants of Sámi early childhood education modified their activities according to Sámi culture and they were flexible in their use of space and time in a way that allowed them to teach nature-related knowledge and respect it in a culturally sustainable way (see also Laine 2016). Nature-related knowledge and connecting with it is the basis of Sámi identity (Markkula & Helander-Renvall 2014). This is supported by the usage of Sámi languages in every situation as educators suggest.

A sustainable future and a new kind of building a sustainable future start with early childhood education. In the end, there is no other way than education to a sustainable future. Sustainable education influences individuals' learning, awakening, behavior, and choices. The courage and strength of educators and teachers to work to build a sustainable and vibrant future is essential in shaping the worldview of future adults and pursuing sustainable development and ecosocial education. Children are ultimately innovators and decision-makers: children have no prejudices or barriers, patterns or perceptions that limit functions and thinking (Määttä, Hyvärinen, Äärelä & Uusiautti 2020).

Limitations and Future Research Suggestions

This study was done with the interview method with educators. There are two shortcomings to this. First, it reveals the ideas of educators but not the ways children or parents think about the everyday implementation or how it should be organized. The second challenge with this kind of research is the personal view. Narrations might be idealistic or trying to please the researcher, not telling so much about the reality of implementation. What is needed to deepen in the future research is the understanding of the realization of everyday sustainable education.

Suggestions for further research include the development of support for professionals to use Sámi pedagogical means when working with Sámi children. By Sámi pedagogical means, we mean the Sámi ways to raise children and to educate them. Most of the educators are trained in the majority culture systems where they have little or no support for their work in Sámi early childhood education. Sámi children need early education based on their own culture, build on Sámi pedagogy, and using Sámi languages. To implement this, the Sámi educators need more knowledge of Sámi pedagogy. Here the elders play an important role as transmitters and models. The Arctic

sustainable Sámi early childhood education needs continuous and active collaboration with local elders, and this should be supported by research.

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