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Mentoring: Helping Youth Make a Difference in STEM

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Abstract

Mentoring is a life-long approach to building positive, supportive relationships, self-confidence and increasing academic performance. In this article, I present how a college-based summer camp, designed to engage youth in increasing interests in STEM, Healthcare, and Teacher education, by helping youth build self-confidence and career interests through a Vertical Mentoring model. An exploratory case study approach is used to gain insight into how the model shaped youths' interactions in learning concepts in STEM. Middle school participants completed a self-efficacy scale and career inventory of perceptions, learning and academic interests. Middle school youth and mentors provided insight on their attitudes, interests and overall satisfaction about the program experiences. Findings interpreted based on the tenets of positive youth development implemented and provides an anchor for additional mentoring studies. Self-efficacy results indicated that students were motivated in utilizing social resources and supports but rarely sought assistance from others. Drawing from the interview responses from mentees and mentors, the Vertical mentoring model afforded youth increased social interactions and opportunities in learning about STEM concepts outside of their home and school settings. Thus, students with no interest in STEM prior to the college-based camp did benefit positively from the STEM mentoring opportunity.

Introduction

In terms of informal programs, one of the missing pieces in ensuring participants are motivated to pursue careers in STEM is mentoring. With still few longitudinal research studies of formal mentoring in informal settings (Center for Advancement of Informal Science Education (CAISE), 2016), the practice of mentoring has been known to positively influence the behaviors and career choices of many youth and adults. DuBois, Portillo, Rhodes, Silverthorn, and Valentine (2011) work on mentoring programs has noted that these programs are becoming more "commonplace in today's society" (p. 58) but the structure of these programs vary greatly. These mentoring programs often fail to provide youth with opportunities to reflect critically and to engage in discourse about their own experiences and understandings. Today's young adolescents need more opportunities to empower them to engage in challenges that are equitable and to develop their own personal identities (Association for Middle Level Education (AMLE), 2012). Adolescents can develop positive identities through mentoring interventions in informal programs, which can also provide supports that are also attentive to the young adolescents' culture, language and identity (AMLE, 2012; National Research Council, 2009). This paper shares how mentoring practices during a two-week summer program has benefitted youth by building supportive relationships and increasing interests in STEM, Healthcare, and Teacher education.

The objective of the paper is to explore how the college-based camp was able to utilize a mentoring platform, Vertical Mentoring to build the confidence among youth: middle school camp participants (mentees), high school student volunteers (mentors), and college student (mentors). Although mentoring is considered to be a standard practice in many afterschool and traditional school settings (Mentoring, 2010), by promoting the social and emotional success of youth, yet it appears to still lack research on its use in an informal environment such as a summer STEM/Health/Teacher Education camp. The critical questions the study south to answer: How does the mentoring opportunities in the Junior Seahawk program influences youths' confidence towards STEM concepts and careers aspirations? How does this experience influence self-efficacy of learners?

Successful mentoring methods such as the Big Brother Big Sisters (BBBS) have provided the platform for many after school or informal programs to create fun opportunities that guide and encourage youth to achieve academic success and develop career interests (Schwartz, Rhodes, Chan, & Herrera, 2011). Mentoring supports the positive interactions between young people and an older experienced person as they work on tasks to develop career interests and build knowledge. Through this process of providing service to others it helps motivate young adolescents to become more engaged in experiences within their communities and to tackle difficult problems, such as individual differences, bullying, academics (Farber & Bishop, 2018). The specified pairing of youths with experienced, caring volunteers trained to provide encouragement, education, and direction is essential for all mentoring programs to be effective (Schwartz et al., 2011).

Mentoring allows opportunities for comprehensive discussions among youth mentees and peers mentors about career concepts and values, while increasing social skills of both mentee and mentors as they interact with new people and places (Karcher, Davis, & Powell, 2002). The summer camp targeted economically disadvantaged and underrepresented youth, in particular, to increase their ability to interact with STEM, Healthcare, and Teacher education professionals through this mentoring framework. These children have limited opportunities to attend specialized camps on the university's campuses and often perform meagerly in school subjects such as reading, math, and science. They also tend to have deficient behavior and disparities in their health care. Chaskin and Hawley (1994) revealed that many at-risk youth tend to isolate themselves from others at school and most likely lack a supportive environment to provide positive social and emotional support. Mentoring relationships that work allow for youth to develop trust and feel at ease talking and sharing their thoughts and goals with mentors. Programs that would enable young people to build confidence and are supportive of cognitive and social-emotional needs while helping the mentee develop their identity can lead to positive outcomes in academics, social, emotional, and career aspirations, especially in high need areas such as STEM, health care, and teacher education. Before sharing the findings, I begin with an overview of mentoring youth research and the youth mentoring model. I will explain the components of the vertical framework and how it was implemented. Highlighting our findings on how it aided young people to achieve positive learning outcomes in STEM, Health, and Teacher Education areas.

Theory of Mentoring

Mentoring is often viewed as a system to connect individuals in developing conversations of similar interests. It also is known to help in building social skills and fostering personal development during periods of transitions for individuals. The view of providing support to succeed in academics and social development is linked to the theory of developmental mentoring. This form of mentoring centered on the "connectedness and academic achievement" of youth significantly threatened by many of today’s communities, which are becoming more isolated and less socially supportive as indicated Karcher et al. (2002).

In terms of levels of support, mentoring can be considered a multifaceted construct (Fullick-Jagiela, Verbos, & Wiese, 2015). Support types such as career and psychosocial serve as the basic tenets to add in guiding and advising mentees in professional and personal life experiences. Positive youth development (PYD) approach has provided solid elements to identify practices of success and lack of success in influencing youth behaviors and potential career influences. The objectives of PYD aid in identifying impact this mentoring model plays in providing positive environment for youth development (Catalano, Berglund, Ryan, Lonczak, & Hawkins, 2002, p. 5). Constructs of the objectives include: bonding, resilience, social competence, emotional competence, cognitive competence, behavioral competence, moral competence, self-determination, spirituality, self-efficacy, clear and positive identity, future belief, positive behavior, prosocial involvement and prosocial norms (p. 15).

The constructs of risk, resilience, and prevention-focused set the platform for Karcher’s (2001) adolescent connectedness framework, which serves to retain children’s motivation and interests in academic success and career pursuits. The social learning theory of change that focused on situated learning set forth by Lave and Wenger's (1991) concept of community of practice is also well suited to address the social and personal transformations of knowledge that occurs between mentees and mentors. The positive supportive relationship is framed on the exchange of ideas and sharing of experiences. This idea places children in a context where they can not only interact with a problem but also collaborate with novices (peers) and experts (mentors), while engaging in a socially supportive community of practice. This practice can ultimately lead to a unique mentoring environment that offers a sense of the cultural norms that enable social and emotional development of youth. The development of the Vertical Mentoring Model (Reid-Griffin, 2015) used in this program specifically addresses the nature of the supportive relationships within each mentoring level.

Youth Mentoring Model

Before the development of the Vertical Mentoring Model (Reid-Griffin, 2015) used in this research study, the Rhodes’ Youth Mentoring Model (2004) was examined to help identify some core aspects of building and supporting mentoring relationships among participants in this enrichment summer program. Rhodes' model (2004) is conceptually based on the interactions of children and adolescents with adult mentors as it influences three areas of development: social, emotional, cognitive and identity. The design of the model situated around the theory of social interactions and the basic tenets of child and adolescent development: social, cognitive and identify development. The mentor has the crucial role of encouraging children/mentees so that they can "acquire and refine new thinking skills while becoming more receptive to mentors' values, advice, and perspectives" (Rhodes & Dubois, 2008, pg. 256). In addition to engaging in these social development experiences, they are also able to construct their own identities. Building on the similar constructs of the Rhodes model (2004), the Vertical Mentoring Model (Reid-Griffin, 2015) is comprised of three-tiered stages that support cognitive development by providing opportunities for mentees to gain a sense of their current and future identity development. The design of this model allows for the social development among adult mentors who are a part of the post-secondary STEM, Health, and education programs to engage in mentoring relationships with career professionals and college faculty. The stages of the model that address youth mentoring [Level 1- Middle school students & Level 2-High school students] focus on relationship development, cognitive growth and identity as it relates to their career aspirations and current interests. The conceptual framework, Collaborative Actions of Community by Erdogan and Stuessy (2015) helped in framing the stages of the Vertical Mentoring model (Figure 1) and defining the roles of the key players in this mentoring environment.

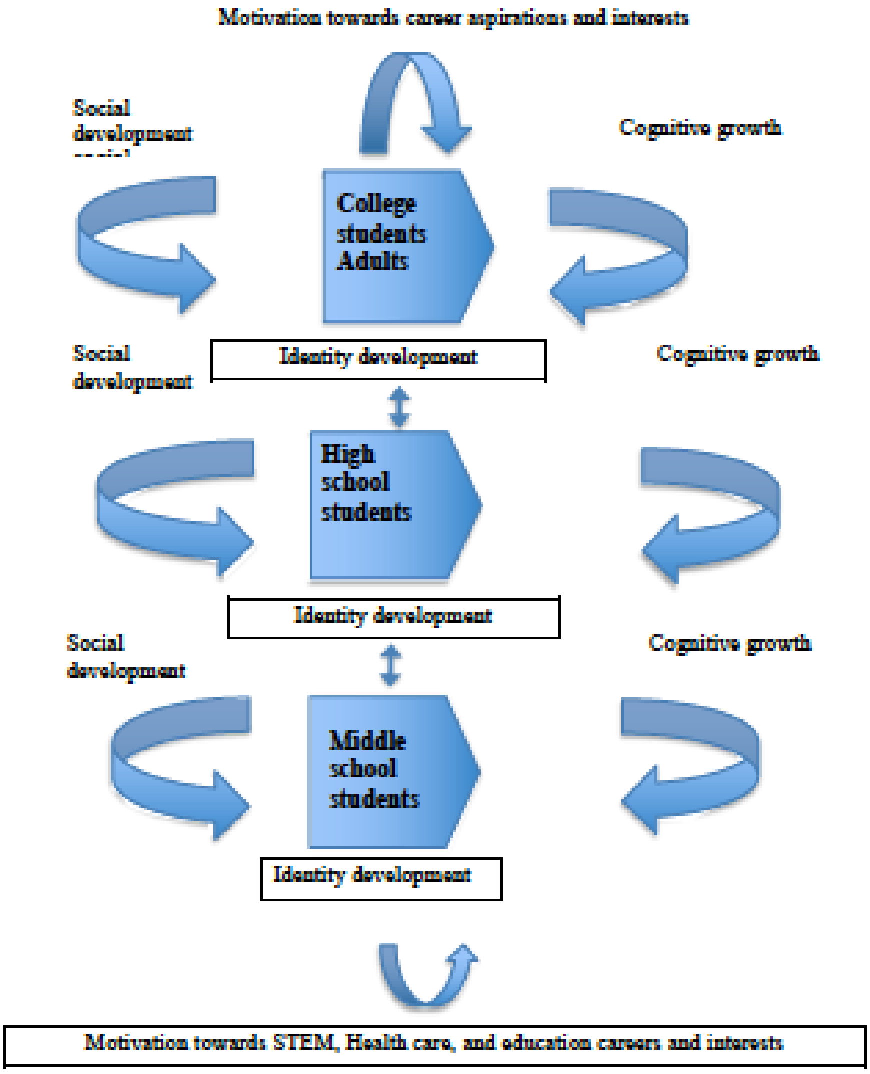

Figure 1. Vertical Mentoring model (Reid-Griffin, 2015) provides a platform for youth and adult mentoring targeting social, cognitive, and identity development

The structure of the model starts with middle school students being mentored by their peers, high school students, and college students working with the summer program as STEM, Health or teacher education experts. Then at the next level, mentoring takes place among high school students, teenagers by college students, adults working with the program, and volunteer adult community mentors. The last level of mentoring occurs between the college students and adult volunteers with the program by instructional camp staff, university STEM, Health and education faculty and community professionals in these career fields. The dynamic features of the model provide for continued improvement in the areas of social and identity development as well as cognitive growth for both mentee and mentors.

This vertical structure for mentoring allows for the fostering of success among participants in the program as they engage in real-world activities in STEM, Health, and education. Motivation is also heightened with this model as students and adults can gain positive self-efficacy and confidence as they have interactions with a broad range of experts in STEM. As Monk, Baustian, Saari, Welsh, D'Elia, Powers, Gaston, and Francis (2014) indicated from their work with mentors the diversity of instructors involved in this model allow all students and adults feel a sense of giving back to the community and leads to "improved teaching, mentoring, and communication skills" (pg. 394). In this paper, the author describes work with using this Vertical Mentoring approach (Reid-Griffin, 2015) with middle school students, high school students and college students during a college-based summer program in STEM, Health, and Teacher education. Exploring how to get the students more engaged and interested in these careers as they became self-motivated and invested in program outcomes. Through the mentoring relationships, the author seeks to provide opportunities for youth to practice communication skills without feeling embarrassed and formal presentation experiences. Informal programs that include mentoring opportunities, such as the Junior Seahawk Academy, can transform students' perceptions and interests in these areas as well as provide monitoring of their academic progress.

Context

The Junior Seahawk Academy program has been in operation since 2003. The program provides a platform for middle school children to attend a college campus and learn from college faculty and students about STEM related fields. The program was revised to provide opportunities for former participants, rising sophomores and older high school students, to continue their interests in these fields and share their knowledge and academic experiences with younger participants. The expansion of the mentoring practice now includes college students interested in STEM areas and other adults in the community. The program took place each summer for 2 weeks from 8:30am-12:30pm. The high school students, college students and adult mentors participated in a 1-day training to prepare them for the program activities and reviewing mentoring procedures.

Throughout the week of the program, mentors were assigned to work with 1-3 middle school campers by engaging in conversations about career interests, hobbies and activities for the program. Typical day included students meeting together in the morning for group activity and then moving to their assigned grade level group. Each grade level group had a full time certified middle school instructor along with 3-4 high school or college mentors to assist. Program staff had backgrounds in STEM education and they taught one focus area of the camp to the students. The curriculum was developed by each individual teacher based on the camps' theme for the summer. For this summer's session theme, "Living in the Port City" students worked on activities to educate them on opportunities in the community related to STEM. After completing instructional activities, mentors met with their students and engaged in practices described by PYD constructs of bonding, resilience, social competence, emotional competence, cognitive competence, behavioral competence, moral competence, self-determination, self-efficacy, clear and positive identity, future belief, positive behavior, prosocial involvement and prosocial norms (Catalano, Berglund Ryan, Lonczak, & Hawkins, 2002, p. 5).

The youth, who participated in the program as campers or volunteers or mentors, were from a diverse background as the demographics of the community has a wide array of ethnic and socioeconomic backgrounds. The region has a distinct demographic and economic composition creates unique challenges for local families and educators. Here, affluent gated subdivisions and beach resorts are flanked by both impoverished rural communities and urban areas with alarming levels of poverty and crime rates that rival those of much larger cities. Based on social capital, a notion developed by Coleman (1988) to describe the social structures within one's community, individuals relied on these structures to create resources that are devoted to improving one's skills, behaviors and life chances (Furstenberg & Hughes, 1995). Thus, while growing up mere miles from a prestigious state university, too many students find themselves worlds away from the possibilities that higher education offers. This program offered student gains in social capital through knowledge of college programs, career opportunities in STEM and social networking with abilities to ask mentors for accurate advice. The learning opportunities in STEM career pathways also provided transformative effects on how participating youth achieve their goals and develop a sense of belonging. This opportunity creates meaningful connections that are centered on three constructs: communication, trust and effort. In addition to empowering youth in their own development but in that of their peers through mentoring. In the next 3-5 years the author hopes to see an increase in the test scores of camp participants and more interest in STEM and seeking higher education by all student participants.

Method

This research takes on an exploratory case study approach to gain insight into how the Vertical Mentoring model might affect the youth interactions in learning about STEM concepts, health and teacher education (Stake, 1995). Using both qualitative and quantitative measures to provide a descriptive approach of how this form of mentoring added to an area of research where little has been conducted. The study sought to answer the following research questions:

1) How do the mentoring opportunities in the Junior Seahawk program influence youths' confidence towards STEM concepts and careers aspirations?
2) How does this experience influence self-efficacy of learners?

The setting of the Junior Seahawk Academy was on the campus of a regional university in the southeastern region of North Carolina. The participants of this program and study comprised 50 middle school students. There were seven high school student mentors, five college student mentors and eight adult mentors who participated in the study. The middle school and high school students recruited from three local school districts in southeastern North Carolina. The schools are known to have higher populations of minority ethnic students, a significant number of students receiving federal assistance for lunch (free/reduced lunch) and are a part of populations that are largely underrepresented in STEM, Health, and teacher education careers.

The self-efficacy scale developed by Bandura (2006) was administered to the middle school students during the first day of the college-based camp in a large classroom setting. They were asked to complete the instrument fully to the best of their ability as a measure for research to explore their values toward learning during this experience. This instrument was used only with the middle school camp participants and selected because of its validity (Bandura, 2006). The instrument included a scale range of 0-100 with indicators for the following areas for self-efficacy: 1) Enlisting Social Resources; 2) Academic Achievement; 3) Self-Regulated Learning; 4) Self-Assertiveness; and 5) Enlisting Parental and Community Support.

During the last week of the summer program, randomly select middle school students (n=7) were asked to participate in focus group session about their learning gains in the areas of STEM, Health, and Education. The students were provided time also to share what they liked and did not like about the program, including their thoughts on the mentoring sessions. The mentors for the summer program, high school (n=7) and college (n= 4) were also asked to discuss their thoughts on this experience. They shared how their role as mentors influenced their careers interests and shared comments about mentoring work with the younger students. The overarching themes targeted by the mentoring model is presented in Table 1.

Table 1. Mentoring themes

Mentoring Themes	
Social development	• Peer interactions/Social interactions
Cognitive development	• Content knowledge confidence • Skill-set knowledge confidence
Identity development	• Self confidence • Leadership

At the conclusion of the summer camp, a program evaluation survey was distributed to all mentors (high school students, college students, and teaching staff/adults). The electronic survey instrument comprised 21 questions about the program's implementation of mentoring. The survey was developed author and administered on a secure survey management server maintained at the college. A small percentage of the mentors completed the electronic survey (n=5), which was then subsequently analyzed in detail.

The data were analyzed using an exploratory mixed method approach in addressing the implementation of mentoring with the Junior Seahawk Academy program. There were additional qualitative methods used to understand students' perspectives towards the mentoring activities. Behavior observation recordings of mentor/mentee interactions during mentoring sessions and focus group interviews were completed in creating the triangulation strategy for this mixed method study (Creswell, 2003). The additional analysis involved using coding schemes to classify interviews and observation recordings concerning the effects of mentoring towards confidence and careers aspirations.

The focus group interviews with the middle school participants in the Junior Seahawk program took place on the last day of the half-day camp program. Twelve of the 50 participants (n=12) were randomly selected by the researcher to participate in the focus group interview. All of the mentors (n=20) also participated in a separate focus group interview to gauge their thoughts about the program and mentoring interventions used. They were asked questions related to their demographics, such as how they learned about the program, career interests; learning experiences in STEM/Health/Teacher Education and their opinions about the program activities and future events.

Results and Discussion

Analysis of survey and interview data are presented in two stages to reflect the questions that were used to guide the research. The data suggested that participants felt positive about the program's learning experiences in its ability to prepare them for a career in STEM, Healthcare, and Teacher education areas. Regarding how they learned about the program, 11 middle school participants indicated a family member mentioned the program to them and recommended that they participate. Only 1 of the middle school participants said they received the recruitment flyer at a school event. During the focus group interview conducted with the students several selected careers in STEM related field. Some of the careers mentioned were biomedical engineering, marine field, dentistry, game designing, pediatric surgeon, teaching, sports medicine and software engineer. Throughout the week they were engaged in presentations by a dentist, computer engineer, nursing professor and teaching professor. As the students shared their career interests one commented, "I changed my mind when we talked with the dentist. I didn't know what I want to be until they came and talked to us. I plan to be a dentist."

The middle school participants' comments about learning gains in STEM, Health and Teacher Education after participating the program were mostly positive (98%). Some of the children indicated the influence of their previous experiences such as their middle school, family and their roles on a science team during the school year.

Other children mentioned how this particular camp experience influenced their learning of the STEM and Health topics. A few of the comments were as follows: "it was fun, I learned about cardio, Spheros, and teaching"; "I learned STEM through my robotics and design & modeling classes"; "I learned a lot about different ways to do science and math"; "STEM from school, healthy living, and my sister is working on her Masters in the Education school." There were some students (2%) that were not happy about having to attend the program as they indicated, "mom made me come" during the focus group session and program survey. For the focus group sessions with middle school students and mentors, many of the comments revealed positive learning gains from the program.

Mentees (Middle school students):

- I should try new things, be cool and the ability to remake project idea
- learned a lot about different ways to do science and math
- Everything involves science
- ….you have to be focused, follow directions...planning ahead
- Always try
- There is more to engineering than the design
- Helping with project ideas
- Completing worksheets

Mentors (high school/college students):

- Helped with making sure materials for the sessions were distributed
- Making sure students were on task and engaged
- Went on field trips
- I also helped with some experiments and getting them ready for the showcase at the end of the camp

The final comments from the mentors during the focus group session revealed that although the overall mentoring experience provided the participants good learning gains and opportunities to share their knowledge, there were limitations in the research. This included the amount of time students participated in program as well as the length of the mentoring session with students. All of the mentors indicated that the amount of time they were able to spend with the campers for mentoring was not enough. Many noted that much of the mentoring occurred as they traveled with students during STEM field experiences. Additional comments from mentors during focus group interview session conducted at the end of the camp session.

> Student Comment A (high school): The aspect of the program that I liked was working with the kids and doing a whole bunch of different activities. I might be willing to participate again, depending on if I have the time…..
>
> Student Comment B (high school): I would be willing to participate in this again because I could learn different skills I need for college and high school. The aspect of the program that I liked was the one-on-one teaching. And the people coming there to teach the kids different things about life and careers and college and everything.
>
> Student Comment C (college): One aspect of the program I really liked was working with the kids, working with the…and the other little robots. And I would consider taking a career in STEM, like engineering, thanks to this program.

Data Analysis

The results indicated overall satisfaction with the program and activities from middle school participants who fully completed the Self-Efficacy scale complete (N=29). Due to timing of scheduled activities, other campers were not able to complete the scale, so their responses were not included in the data analysis and findings. The results displayed in Table 2, Table 3 and Table 4 present the response mean and standard deviation (SD) for each scale item. The Cronbach's alpha was .965 indicating scale reliability. The findings offered insight on students' satisfaction and perceived self-efficacy with Junior Seahawk program. Based on the middle school participants responses to the scale the standard deviations (SD) ranged from 28.00 to 43.00 indicating strong correlation of data around the mean responses to the scale items. In addressing the research question about the influences of this experience on students' self-efficacy the responses from the scale were modest for the scale items for "enlisting social resources", "academic achievement", "self-regulated learning", "leisure time/extracurricular activities", "meeting others' expectations", "social self-efficacy", "self-assertiveness" and "parental/community support." While not all students completed the scale they provided some feedback on their satisfaction with the program and mentors on an end of the program evaluation completed on the final day of the camp.

Based on the responses from the scale there was a moderate influence of others for support according to the instrument. The mean for enlisting social resources ranged from 53-61. The highest mean value (61.4) was for the statement receiving help from teachers while seeking peer help was the lowest mean at 53. In seeking support from other adults and peers with social problems, the mean score was roughly the same at 54. See Table 2 for a summary of response for the Social Resources and Parental and Community Support sections of the Bandura (2006) instrument. The part of the scale addressing Parental and Community Support had mean scores ranging from 40-74. Participants indicated a more significant rating for seeking help from parents or guardians with problems. The lowest mean score was seeking help from people outside of school reporting the limitation in participants' social interactions outside of their home and school environments. Building on mentoring methods with community supporters and volunteers in follow up program sessions can lead to participants' perceptions of social interactions being greater and occurring more frequently.

Table 2: Summary of social resources &parental and community support responses

	M	SD
Social Resources		
Get teachers to help me	61.4	34.0
Get another student to help me	52.8	38.6
Get adults to help me	54.5	41.8
Get a friend to help me	54.1	40.2
Parental & Community Support		
Get my parent(s)/guardian(s) to help me	74.5	37.9
Get my siblings or other family members to help me	48.3	43.9
Get my parent(s)/guardian(s) to take part in school activities	55.2	39.5
Get people outside the school to take an interest in my school	40.3	40.8

Note: As shown in the table the response percentages for question items and corresponding item Mean (M) and Standard Deviation (SD). N= 29. Scale survey was as following: 0=Not at all 10 20 30 40 50=Moderately 60 70 80 90 100=All the time

For the Junior Seahawk Academy program, the mentoring model provided opportunities for all participants, middle school students, high school students, and college students to benefit positively from the effects of mentoring on confidence towards STEM concepts and career aspirations. Although the mentoring model may not allow for all mentoring encounters to influence self-efficacy of learners, it did foster a sense of community, preparedness, and career readiness in STEM, Health, and Teacher education areas. In Tables 3 and 4, summary responses on Self-Efficacy indicated students were moderately confident and motivated in these response areas. The standard deviation ranged from 28 to 42.

Table 3. Summary of self-efficacy responses

	M	SD
Self-Assertive Efficacy		
Express my opinions when other classmates disagree with me	65.2	40.9
Stand up for myself when I feel I am being treated unfairly	79.3	34.3
Get others to stop annoying me or hurting my feelings	77.2	38.1
Stand firm to someone	70.3	41.9
Self-efficacy for Academic Achievement		
Learning mathematics	81.4	28.9
Learning Algebra	64.1	37.6
Learning Science	80.0	29.8
Learning Biology	69.3	34.3
Reading, writing (Language arts)	79.7	30.9
Computers	74.5	37.6
Learning a foreign language	54.8	39.9
Learning social studies	75.5	34.2
Learn English grammar	69.3	39.5
Self-efficacy for self- regulated learning		
Finish my assignments	68.3	36.9
Get myself to study when there are many other interesting things to do	58.3	30.2
Always concentrate on school subjects during class	70.7	31.6
Take good notes	60.7	34.3
Use the library to get information	57.6	41.1
Plan my schoolwork for the day	53.4	39.1
Organize my schoolwork	65.5	37.7
Remember information	70.3	33.9
Arrange a place to study without distractions	55.5	36.3
Get myself to do school work	71.1	39.1

Note: As shown in the table the response percentages for question items and corresponding item Mean (M) and Standard Deviation (SD). Participant responses, n= 29.

Table 4. Summary of self-efficacy responses

	M	SD
Self-Efficacy for Leisure Time skills and extracurricular activities		
Learn sports skills well	67.9	38.1
Learn dance skills well	47.9	40.0
Learn music skills well	54.1	39.8
Work on the school newspaper	42.4	39.2
Serve in school government	46.2	38.6
Take part in school plays	48.9	42.4
Do regular physical education activities	67.2	41.1
Learn the skills needed for team sports	64.5	42.4
Self-efficacy to meet others' expectations		
Live up to what my parents expect of me	80.3	31.7
Live up to what my teachers expect of me	62.4	40.0
Live up to what my peers expect of me	61.4	40.1
Live up to what I expect of myself	88.6	28.0
Social Self-Efficacy		
Make and keep friends of the opposite sex	73.1	37.8
Make and keep friends of the same sex	71.0	40.1
Carry on conversations with others	70.3	38.7
Work well in a group	71.7	33.4

Note: As shown in the table the response percentages for question items and corresponding item Mean (M) and Standard Deviation (SD). Participant responses, n= 29.

In building on the importance of peer mentoring and community learning the Vertical Mentoring Model (Reid-Griffin, 2015) provided a platform for students to gain confidence towards STEM content knowledge. It also allowed for students to work with others as they learned new skills and shared ideas without the feelings of intimidation. In terms of the constructs to indicate Positive Youth Development approach being an influence on the program, it was noted by their feedback and active engagement with mentors throughout the program sessions.

Furthermore, in the implementation of the mentoring model, we explored whether interactions and developmental changes caused participants and mentors to pursue additional after-school and summer STEM-related activities. In developing a system for efficient mentoring as DuBois et al. (2011) researched, the idea of effective mentoring programs for youth, in general, is much easier to visualize than other approaches to youth service. Through mentoring, the problems or absence of role models was identified by the overall number of professionals in selected STEM and education roles, as well as the lack of diversity of these persons. Through this effort, we were able to determine how this mentoring approach is useful in motivating youth in careers related to STEM, Health, and Teacher education. The interactions provided through this mentoring framework allowed mentee and mentors to learn about STEM careers that are not as well-known by youth and practice new skills (Dworkin, Larson, & Hansen, 2003). Participants of the Junior Seahawk Academy program indicated that they enjoyed the mentoring and collaborative opportunities provided. Excitedly, the program continues to expand the number of youth seeking to participate in programs.

Although mentor programs have served diverse populations of youths, including girls only programs, ethnic minorities, and various age groups, little is still known about processes and outcomes specific to these groups. The lack of research assessing gender, racial, and other group differences may, in part, be caused by limitations in the measurement of mentoring processes and constructs (Rhodes, Spencer, Keller, Liang, & Noam, 2006). The research data lends further support on how the development of healthy relationships can occur among diverse populations of youth.

Anecdotally, one mentee cited specific benefits, as a racial minority in the program, he was able to experience those positive dynamics of mentoring by engaging in conversations and activities with guidance from a high school mentor.

> Middle school participant: "I really enjoyed the mentoring piece and collaborating with other students who are also interested in science and math."

Conclusions and Next Steps

In building on the importance of learning STEM and providing platforms for this learning to occur, programs that support hands-on learning and peer mentoring is what motivates young adolescents (Farber & Bishop, 2018). The findings suggested that the implementation of this particular mentoring model is essential as well as planned curriculum/activities to support and foster the applicability of being in these fields. Community-based programs provide resources to foster youth engagement, involvement and leadership which is likely to help youth achieve personal interests and develop a sense of self efficacy and collective efficacy (Smith, Osgood, Caldwell, Hynes, & Perkins, 2013). The Junior Seahawk Academy provides a shared community in which individuals, both youth and adults feel connected and supported as they learn and engage in STEM opportunities.

As Price, Kares, Segovia & Loyd (2018) research on the importance of program staff in programming supported by PYD, this study was able to provide some insight to how a new approach to mentoring can offer youth the tools for positive behaviors and success in STEM. While future research is needed regarding a longitudinal study to gather data over a more extended time-span to strengthen findings on self-efficacy the study resulted in additional youth wishing to serve in mentoring roles for the programs' future sessions. Further work will continue in seeing how this model will help to provide additional insight into the gains for mentee and mentors after taking part in mentoring opportunities with youth. The findings provide an anchor in reporting how the Vertical Mentoring Model allows for valuable learning; high intrinsic motivation focused concentration on personal identity development, social and cognitive growth (Rhodes et al., 2006). Despite the limitations, this study represents an essential step in considering the pivotal role aspects of a mentoring model and how the relationships influence the benefits of youth pursuing careers in STEM, Health, and Teacher education.

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The Development and Validation of Turkish Version of the Elementary Teachers' Efficacy and Attitudes towards STEM (ET-STEM) Scale

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Abstract

The purpose of this study was to adapt the Elementary Teachers Efficacy and Attitudes towards STEM Survey (ET-STEM scale; Friday Institute for Educational Innovation, 2012) into Turkish and test the validity and reliability of the instrument. ET-STEM was administered to 313 elementary teachers from different provinces of Turkey. Exploratory and confirmatory factor analyses were conducted to examine the structural validity of the scale. According to exploratory factor analysis results, the ET-STEM survey consists of nine factors. The values of Cronbach's alpha of the factors ranged from 0.891 to 0.964, and corrected item-total scale correlation ranged from 0.313 to 0.417. After the exploratory factor analysis performed, the ET-STEM was administered to 213 elementary school teachers. The results obtained from the confirmatory factor analyses demonstrated adequate reliability and validity for measuring the STEM competencies and attitudes of elementary school teachers.

Introduction

Engineering and science industries are vital source of developed countries' economic growth. It is therefore not surprising to see substantial increase in interest and investment in science, technology, engineering, and mathematics (STEM) education from governments. In today's world, global competitiveness requires countries bring innovation and their capacity to innovate to market (MITRE, 2016). Developed countries came to the realization that a blended, well-reasoned, and "whole-of-government" approach is required to foster innovation, boost productivity and economic growth. Different organizations in developed countries work together to engage young people with STEM, offers professional development opportunities and the curriculum resources for teachers. One developed country example is The United States launched the "Educate to Innovate" initiative to improve American student's capabilities in the areas of STEM. The push for improving STEM education has been a priority for the USA for the following reasons: (1) the lack of information on STEM subjects (2) a shortage in STEM professionals (3) the lack of information on STEM professional areas (4) young people's negative perceptions and decreased interest of STEM subjects (Ostler, 2012; Atkinson and Mayo, 2010; Kelley & Knowles, 2016). To address the status of STEM and to reach STEM-related goals, the US and other nations paid attention to STEM education in K12 and college level.

The acronym STEM is a simple acronym, but the definitions of STEM may vary. STEM is often considered viewing different disciplines, those are science, mathematics, technology, and engineering, as a unit. Science, technology, and innovation are important drivers of economic growth in nations. Economic growth relies on generating new ideas and knowledge that can be used to solve a given problem. Any nations that fails to integrate basic and applied research knowledge over international average will be left behind developed countries. Friedman (2005) used a metaphor, "flat world", to describe globalization. More people on the planet participate in economic, cultural, and political activities on a global scale. This means that the way people, information, money, services, and goods supply has changed. When the job market is global, employer can find needed talents from anywhere in the world. When the services and goods are needed, developing countries, such as China, and India, will offer cheap, the same quality products and companies would prefer them to buy. The current situation shows policymakers that countries' citizens lives will be affected by others who live in distant lands. This concerns in developed countries, pushed them to make changes in their education systems, make them questioned their current education pedagogy.

STEM education in K-12 and college settings foster students to make connection across STEM disciplines and as a result students gain skills that are relevant to life (National Research Council, 2011; NRC, 2010). STEM education also makes students better problem solvers, innovators, collaborative; improve students' ability of self-control, critical thinking skills, communication and self-regulation skills (NRC, 2010). With all the possible benefits of STEM education, it is important to support teachers, their teaching practices and teachers' self-efficacy. Additionally, materials should be supplied to implement STEM subjects in the classroom.

Successful integration of STEM areas largely depends on teachers' knowledge about STEM subjects, beliefs, teachers' pedagogical content knowledge, 21st century skills knowledge, and integration knowledge (Yildirim, 2017; Benuzzi, 2015; Hudson, English, Dawes, King, & Baker, 2015; Karakaya & Avgın, 2016; Rogers, Winship, & Sun, 2015; Stohlmann, Moore, & Roehrig, 2012; Wang, 2012; Wang, Moore, Roehring, & Park, 2011; Nadelson et al., 2013). Teacher beliefs are linked to behavior and shape their attitudes about teaching, about students, and about their abilities (Bandura, 1982). Beliefs influence teacher behaviors' in the classroom, teacher planning, decision making (Pajares, 1992; Pintrich & De Groot, 1990; Wallace & Kang, 2004). Teacher beliefs include beliefs about teaching and learning, beliefs about students, beliefs about teachers' role in the classroom, teachers' responsibilities, teachers' abilities (Bayraktar, 2011; Pressley et al., 2003). Teachers' belief together with attitudeand self-efficacy plays a central role in teachers' approach to teach STEM. When teachers are comfortable with STEM content, it affects students' success in the classroom, their motivation to the subject, and their perception towards the lessons (Beilock, Gunderson, Ramirez, & Levine, 2010; Tschannen-Moran & Woolfolk Hoy, 2001). Teachers' self-efficacy also influence students' success and implementation of STEM pedagogy in the classroom (Klassen & Chiu, 2010; Nadelson, Seifert, Moll, & Coats, 2012). Since teacher self-efficacy is content specific, teacher self-efficacy of STEM should be examined within the context and expectations of STEM pedagogy. The context of self-efficacy includes different factors: content knowledge, classroom management, engagement, and outcomes.

In a review of research published in science education, different instruments were developed to assess teacher self-efficacy (Tepe, 2011; Tekerek, Karakaya, & Tekerek, 2016; Bıkmaz, 2002; Bayraktar, 2011). These self-efficacy instruments were created and tested to assess teacher general aspects of self-efficacy (Yoon, et al.,2012). Some widely used instruments are: Teacher Efficacy Scale (TESS) (Gibson & Dembo, 1984), The Science Teaching Efficacy Belief instrument (STEBI) (Riggs and Enochs,1990), The Self-Efficacy Beliefs About Equitable Science Teaching (SEBEST) (Ritter, Boone & Rubba, 2002). The 30-item scale called Teacher Efficacy scale (TES) was constructed to investigate the relationship between teacher self-efficacy and teacher behaviors in the classroom (Gibson & Dembo, 1984). Another instrument called the Science Teaching Efficacy Belief instrument (STEBI) was developed by Riggs and Enochs (1990) to measure science teaching efficacy beliefs among preservice teachers. Similar to these instruments, other instrument The Self-Efficacy Beliefs About Equitable Science Teaching (SEBEST) was designed to measure the socioeconomic factors effects on teacher self-efficacy beliefs in science teaching and learning (Ritter, Boone & Rubba, 2002). Another content-specific instruments were developed to measure teacher self-efficacy beliefs in math teaching (The Mathematics Teaching Efficacy Belief Instrument (MTEBI): Enochs, Smith & Huinker, 2000), in language and literacy (Graham, Harris, & Fink, 2001), in technology (Pan & Franklin, 2011; L. Wang, Ertmer, & Newby, 2004) and in engineering (Yoon Yoon, Evans, & Strobel, 2012).

Even though researchers have developed different self-efficacy instruments for teachers in various setting, there are only a few instruments widely used in STEM education. These instruments are the General Perceived Self-Efficacy Scale (also known as the General Self-Efficacy Scale (Dunlap, 2005; Jerusalem & Schwarzer, 1992), the Academic Self-Efficacy Scale (Painter & Bates, 2012; Pintrich & DeGroot, 1990), the Baldwin Confidence Survey Form (Baldwin, Ebert-May, & Burns, 1999), the Student Attitudes toward STEM Survey (S-STEM) survey (Friday Institute for Educational Innovation, 2012b), the Teaching Engineering Self-Efficacy Scale (TESS) (Yoon et al., 2012). Though different instruments exist in the literature, none of them was originally designed to measure teachers' self-efficacy in STEM in general. A STEM education instrument, Teacher Efficacy and Attitudes Toward STEM (ET-STEM) Survey, was developed to measure changes in elementary teachers' confidence and self-efficacy in STEM subjects (science and mathematics), use of technology in the classroom, 21st century learning skills, leadership attitudes, and STEM career awareness (Friday Institute for Educational Innovation, 2012).

On the other hand, Turkish researchers adopted different instruments to measure teacher self-efficacy towards STEM (Taşkın & Hacıömeroğlu, 2010; Çapa, Çakıroğlu and Sarıkaya, 2005; Yıldırım, 2018; Yerdelen, Kahraman, & Taş, 2016). These adopted instruments for science teachers and none of them were for elementary teachers. Scholars also have recognized the need for measures of elementary teacher self-efficacy and integrated STEM (Yıldırım & Selvi, 2015). Therefore, the ET-STEM scale in this study was adapted to Turkish.

Method

Hambleton and Patsula (1999)'s adaptation process was followed in the study. The adaptation process includes following steps; (1) translation of the whole scale from original language (English) to target language (Turkish), (2) experts meet and through a dialogue decide on the best version of each item, (3) validity and reliability of the adopted scale was calculated by Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA). The translation of the scale was carried out in five stages: (Stage 1) Necessary permissions obtained from Friday Institute for Educational Innovation via email; (Stage 2) After permissions were received from the institute, two experts who were fluent in Turkish and English were invited for translation and back-translation procedures; (Stage 3) To translate the first revised draft of the scale to Turkish, two different experts were invited to English translation process; (Stage 4) Pilot study with three elementary teachers; (Stage 5) Finalization of the Turkish version of the scale. After Friday Institute permission for translation of the scale, two experts who were fluent in Turkish and English translated the scale to Turkish independently, Afterwards, unclear and translated items were examined by the authors and experts. The authors, experts and translators reached a consensus regarding to unclear items and made necessary editing. This version of the scale was translated into English by two language experts. When translation was determined in equivalence between the original ET-STEM scale and the translated form, a pilot ET-STEM scale was administered to three elementary teachers to determine teachers' misunderstandings. Afterwards, the scale was administered to 526 elementary teachers.

Participants

Two independent samples were used in the study. The first sample included 313 elementary teachers, of whom 93 male, 220 females; the second group consisted of 213 elementary teachers, of whom 83 male, 150 females. The experience of the study participants ranged from 1 years to more than 16 years. The participants of this research study are the teachers working for public and private schools (Detailed demographic characteristics of the elementary teachers were shown in Table 1). Exploratory factor analysis (EFA) was carried out on data collected from 313 elementary teachers and the confirmatory factor analysis (CFA) was conducted with second group, 213 elementary teachers. Different sample groups were selected for running exploratory and confirmatory factor analysis to not to replicate the results obtained in EFA. Before participants completed the scale; the teachers were informed about the purpose of this study and were reminded of their right to withdraw from the study at any time. All elementary teachers had volunteered for the study and received no award for their participation.

Table 1. Demographic characteristics of elementary teacher participants

		First Group		Second Group	
		n	%	N	%
Gender	Male	93	23,23	83	38.96
	Female	220	70,28	150	61.04
Experience	0-5 years	63	20,12	55	25.82
	6-10 years	130	41,53	110	51.64
	11-15 years	75	23,96	25	11.73
	16-or more years	45	14,37	33	15.49
School Type	Public School	260	83,06	175	82.15
	Private School	53	20,13	38	17.85
Total		313	100	213	100

Data Analysis

To analyze the data obtained from elementary teachers via ET-STEM scale, descriptive and confirmatory factory analyses were applied. The confirmatory factor analyses generally is used to determine factor pattern of the scale in the target culture (Turkish elementary teachers) and recommended by the researchers (Cokluk, Sekercioglu, & Buyukozturk, 2014). The exploratory factor analyses increase the reliability of the scale by identifying items that needs to be removed. To conduct a confirmatory and exploratory factor analyses two different groups were selected. The confirmatory factor analyses of the scale were performed using the data from 213 elementary teachers and the exploratory factor analyses of the scale were calculated the data from 313 elementary teachers. Since the scale's sample group consisted of 526 elementary teachers, sample size of 500 is very good according to Comrey and Lee (1992). Kas and Tinley (1979) recommended five to ten case per item and in this study the sample group is five times larger than the number of items. Furthermore, Boomsma (1982) recommended a minimum sample size of 200 to obtain reliable results in order to conduct factor analyses. The varimax rotation applied in this study. The varimax rotation produce simple solutions and each factor has small number of variables. This simplifies the interpretation (Kieffer, 1998). While running confirmatory factor analysis, the Goodness of Fit Index (GFI), the Adjusted Goodness of Fit Index (AGFI), the Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI), Standardized Root Mean Square Residual (SRMR), Incremental Fit Index (IFI), and the Normed Fit Index (NFI) statistics were used (Baumgartner & Homburg, 1996; Bentler, 1980; Brown, 2006; Field, 2009; Kılıç & Şen, 2014). Moreover, the correlation analysis was run for determining the relationship(s) between subscales of the STEM scale. The validity and reliability analyses of the scale were calculated using SPSS Statistics (Version 21.0) and LISREL (Version 8). The results of the exploratory and confirmatory factor analyses of the ET-STEM Scale are explained below

Elementary Teacher Efficacy and Attitudes toward STEM (ET-STEM) Scale

The Elementary Teacher Efficacy and Attitudes towards STEM Scale was developed by Friday Institute for Educational Innovation (2012). While developing scale, 228 elementary teachers participated in the study and only an exploratory factor analysis was conducted. Exploratory factor analysis identified nine dimensions with 83 items using a five-pint Likert scale.

Table 2. ET-STEM survey reliability

Construct	Number of Items	Cronbach's Alpha Elementary (n=228)
Science Teaching Efficacy and Beliefs	11	.905
Mathematics Teaching Efficacy and Beliefs	11	.939
Science Teaching Outcome Expectancy Beliefs	9	.854
Mathematics Teaching Outcome Expectancy Beliefs	9	.895
Student Technology Use	8	.943
STEM Instruction	14	.950
21st Century Learning Attitudes	11	.948
Teacher Leadership Attitudes	6	.870
STEM Career Awareness	4	.945

Constructs of ET-STEM Scale

The ET-STEM Scale consisted of nine sub-dimensions. These dimensions were follows as: "STEM Instruction (SI)", "21st-Century Learning Attitudes (CS)", "Science Teaching Efficacy And Beliefs (STE)", "Mathematics Teaching Efficacy And Beliefs (MTE)", "Student Technology Use (TU)", Teacher Leadership Attitudes (TL)", "Science Teaching Outcome Expectancy (SOE)", "Mathematics Teaching Outcome Expectancy (MOE)", "STEM Career Awareness (SC)". The structures, abbreviations and definitions related to the mentioned nine sub-dimensions of ET-STEM were shown in Table 3 (Friday Institute for Educational Innovation, 2012).

Table 3. Definitions of the constructs of the ET-STEM scale

Construct	Abbreviation	Definition
Science Teaching Efficacy and Beliefs	STE	self-efficacy and confidence related to teaching the specific STEM subject
Mathematics Teaching Efficacy and Beliefs	MTE	self-efficacy and confidence related to teaching the specific STEM subject
Science Teaching Outcome Expectancy Beliefs	SOE	degree to which the respondent believes, in general, student-learning in the specific STEM subject can be impacted by actions of teachers
Mathematics Teaching Outcome Expectancy Beliefs	MOE	degree to which the respondent believes, in general, student-learning in the specific STEM subject can be impacted by actions of teachers
Student Technology Use	TU	how often students use technology in the respondent's classes
STEM Instruction	SI	how often the respondent uses certain STEM instructional practices
21st Century Learning Attitudes	CS	attitudes toward 21st century learning
Teacher Leadership Attitudes	TL	attitudes toward teacher leadership activities
STEM Career Awareness	SC	awareness of STEM careers and where to find resources for further information

Results

Exploratory Factor Analysis was conducted with the first group. While using an EFA, the aim was to determine dimensions of the scale and the number of items. Before running an EFA analyses, Kaiser-Meyer-Olkin (KMO) and Barlett test were utilized. The KMO value of 83 items was calculated as 0.788 and the Bartlett test was found to be meaningful (χ^2 28911,185 df= 3403, $p < .05$). Therefore, the data from Turkish elementary teachers were appropriate to run an EFA.

According to Büyüköztürk (2006), when KMO coefficient was greater than 0.60 and the Barlett test was significant, the EFA would be run. Varimax analysis was performed for the ET-STEM. Varimax analyses gather together factors with high correlations (Doğan, 2011). According to Kaiser (1960), one must consider whether a measure is more than an attribute value of 1 in factor selection. Based on the varimax analysis, nine factors' eigenvalues were found to be greater than 1. To calculate eigenvalue, a scree plot method was used. Figure 1 shows the maximum number of factors.

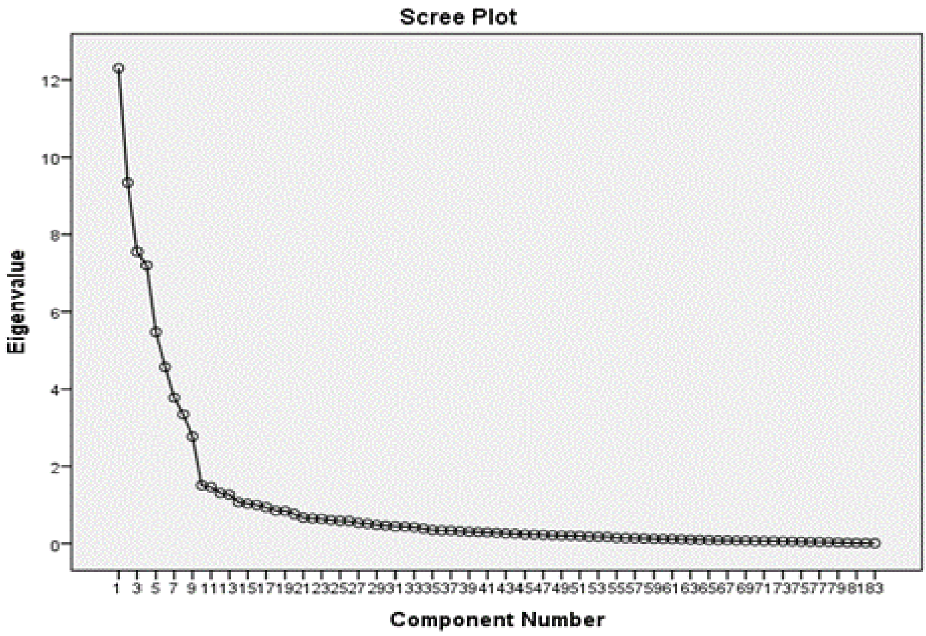


Figure 1. Scatter graph

Reliability Evidence

The ET-STEM's internal consistency coefficients were calculated, and the Cronbach's *αs* for each factor is presented in Table 4. The Cronbach α value of the ET-STEM scale and the subscale values were high. All values were greater than .70 (Tavşancıl, 2002), meaning good reliability evidence. The results of the EFA statistics of the ET- STEM scale (See Table 4).

Table 4. Internal consistency reliability coefficients of ET-STEM scale

Construct	Cronbach's *α*
STEM Instruction	.964
21st Century Learning Attitudes	.935
Science Teaching Efficacy and Beliefs	.956
Mathematics Teaching Efficacy and Beliefs	.908
Student Technology Use	.944
Teacher Leadership Attitudes	.957
Science Teaching Outcome Expectancy	.902
Mathematics Teaching Outcome Expectancy	.891
STEM Career Awareness	.917
T-STEM Scale	.917

Table 5. Results of the exploratory factor analysis of ET-STEM scale

Items	*M*	*SD*	Item-total correlation	*t*-value (bottom 27%, top 27%)	Rotator factor load	Common factor load
STEM Instruction (14 items)						
SI13	4.14	.79	.443	8.788	.877	.786
SI6	4.11	.85	.391	8.612	.873	808
SI7	4.33	.69	.542	11.018	.862	.784
SI9	4.08	.83	.442	9.020	.862	.784
SI4	4.18	.88	.494	9.743	.849	.776
SI3	4.20	.88	.504	9.861	.840	.762
SI10	4.17	.69	.503	9.385	.839	.741
SI14	4.18	.89	.425	8.135	.828	.721
SI8	4.19	.86	.472	9.722	.798	.690
SI2	4.20	.71	.423	7.294	.796	.673
SI5	3.99	.91	.406	8.039	.780	.644
SI1	4.12	.86	.394	6.759	.764	.604
SI12	4.12	.91	.468	11.513	.737	.633
SI11	4.22	.71	.405	7.571	.722	.555
Science Teaching Efficacy and Beliefs (11 items)						
STE11	3.67	1.20	.481	10.800	.928	.885
STE4	3.55	1.26	.437	9.441	.920	.878
STE2	3.61	1.26	.453	9.156	.905	.851
STE6	3.50	1.29	.464	10.225	.900	.841
STE9	3.48	1.10	.482	10.780	.879	.803
STE1	3.90	1.15	.477	10.052	.856	.785
STE3	3.77	1.29	.437	9.795	.830	.750
STE8	3.33	1.22	.459	10.607	.821	.704
STE5	3.89	1.23	.397	7.795	.696	.542
STE10	4.34	.95	.355	6.188	.675	.477
STE7	3.68	1.32	.436	9.570	.600	.445
21st Century Learning Attitudes (11 items)						
CS5	4.64	.50	.374	5.481	.897	.857
CS4	4.56	.59	.327	5.007	.870	.802
CS6	4.42	.68	.338	4.991	.856	.781
CS1	4.61	.53	.356	5.011	.844	.790
CS3	4.66	.54	.338	5.055	.825	.778
CS7	4.56	.64	.364	5.609	.805	.719
CS11	4.51	.58	.353	5.613	.743	.676
CS2	4.60	.58	.371	4.016	.738	.643
CS9	4.57	.59	.353	5.899	.708	.569
CS10	4.32	.87	.328	4.646	.620	.530
CS8	4.66	.57	.315	6.009	.607	.491
Mathematics Teaching Efficacy and Beliefs (11 items)						
MTE8	3.26	1.17	.405	8.032	.857	.766
MTE4	3.56	1.12	.383	7.541	.823	.707
MTE6	3.49	1.21	.388	7.213	.822	.702
MTE11	3.87	1.01	.417	8.355	.800	.702
MTE3	3.87	1.09	.359	6.384	.785	.644
MTE9	3.41	1.04	.409	8.598	.762	.633
MTE2	3.57	1.12	.404	7.876	.719	.609
MTE1	3.89	1.01	.339	7.342	.715	.533
MTE10	4.29	.91	.344	6.133	.544	.418
MTE7	3.96	1.13	.366	4.973	.464	.360
MTE5	4.18	1.07	.388	4.445	.464	.339
Student Technology Use (8 items)						
TU2	4.33	.87	.404	5.529	.884	.808
TU3	4.38	.84	.393	4.922	.873	.787
TU1	4.06	.1.06	.341	5.927	.862	.779
TU6	4.15	.89	.320	5.626	.858	.806
TU7	4.02	.89	.333	5.306	.850	.795

TU5	3.90	.84	.390	4.508	.803	.735
TU8	4.33	.90	.311	4.474	.708	.685
TU4	3.55	1.07	.364	5.897	.701	.585
Science Teaching Outcome Expectancy (9 items)						
SOE7	4.14	.78	.300	2.566	.842	.733
SOE2	4.15	.82	.313	3.335	.789	.643
SOE1	3.99	.88	.319	4.073	.782	.626
SOE4	3.67	.96	.390	2.597	.781	.661
SOE6	3.80	.82	.380	2.254	.754	.648
SOE3	4.19	.82	.340	2.564	.740	.575
SOE8	4.38	.79	.347	4.357	.704	.526
SOE9	4.06	.90	.310	2.088	.674	.484
SOE5	3.40	1.09	.367	3.101	.643	.464
Teacher Leadership Attitudes (6 items)						
TL4	4.65	.62	.340	5.884	.924	.910
TL5	4.66	.61	.411	6.605	.890	.884
TL3	4.67	.61	.301	4.653	.880	.805
TL6	4.57	.64	.311	4.629	.878	.767
TL5	4.66	.65	.411	6.605	.870	.884
TL1	4.62	.66	.397	4.255	.838	.818
Mathematics Teaching Outcome Expectancy (9 items)						
MOE7	4.07	.78	.391	5,654	.812	.671
MOE4	3.58	1.01	.336	6,388	.788	.680
MOE3	4.06	.82	.382	5,705	.749	.605
MOE6	3.60	1.03	.380	7,434	.748	.614
MOE5	3.53	.96	.334	4,577	.716	.540
MOE1	3.81	.86	.378	5.164	.704	.524
MOE8	4.26	.87	.344	5,197	.697	.494
MOE2	4.01	.86	.313	3.517	.641	.470
MOE9	3.99	1.00	.381	4.056	.619	.440
STEM Career Awareness (4 items)						
SC4	4.18	.88	.335	4.515	.795	.833
SC2	4.20	.70	.325	4.080	.793	.842
SC3	4.21	.88	.381	3.469	.777	.762
SC1	4.11	.86	.351	3.400	.681	.722

***** factor loads value is lower than .30 were not shown in table (Çokluk, Şekercioğlu, & Büyüköztürk, 2014).

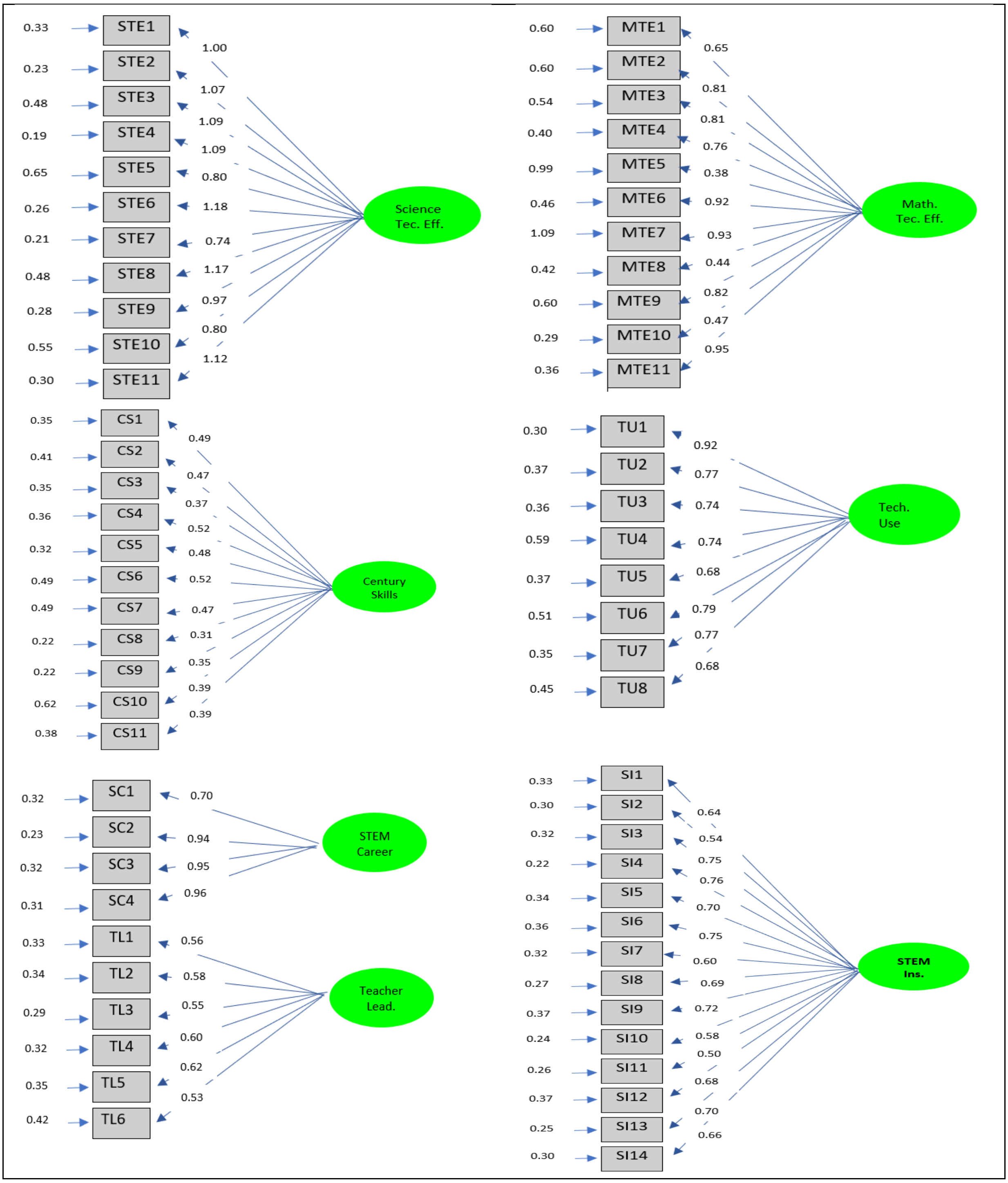
The Cronbach's Alpha value was .917 for the entire ET-STEM scale, .964 for the STEM Instruction dimension, .935 for the 21st-century learning attitudes dimension, .956 for Science Teaching Efficacy and Beliefs dimension, .908 for Mathematics Teaching Efficacy and Beliefs dimension, .944 for Student technology use dimension, .957 for teacher leadership attitudes dimension, .902 for the Science Teaching Outcome Expectancy dimension, .891 for the Mathematics Teaching Outcome Expectancy dimension and .917 for the STEM career Awareness dimension.

Alpha coefficients were calculated for Science Instruction dimension, 21st-century learning attitudes, Science Teaching Efficacy and Beliefs, Mathematics Teaching Efficacy and Beliefs Student technology use, teacher leadership attitudes, the Science Teaching Outcome Expectancy, the Mathematics Teaching Outcome Expectancy and STEM career Awareness factors and found all were higher than .70 (Tavşancıl, 2002).

The variance quantities were ranked as follows: STEM Instruction was 14.824%, Science Teaching Efficacy and Beliefs was 11.258%, 21^{st} Century Learning Attitudes was 9.104%, Mathematics Teaching Efficacy and Beliefs was 8.678%, Student Technology Use was 6.598%, Science Teaching Outcome Expectancy was 5.505%, Teacher Leadership Attitudes was 4.454%, Mathematics Teaching Outcome Expectancy was 4.028%, and STEM Career Awareness was 3.336. After factor rotation, the number of items for each factor was determined :STEM Instruction included 14 items with factor loadings ranging from .722 to 877; Science Teaching Efficacy and Beliefs consisted of 11 items with factor loads ranging from.600 to .928; 21^{st} Century Learning Attitudes consisted of 11 items with factor loads ranging from.607 to .897; Mathematics Teaching Efficacy and Beliefs consisted of 11 items with factor loads ranging from.464 to .857; Student Technology Use consisted of 8 items with factor loads ranging from .701 to .884; Science Teaching Outcome Expectancy consisted of 9 with factor loads ranging from.643 to .842; Teacher Leadership Attitudes consisted of 6 items with factor loads ranging from .838 to .924; Mathematics Teaching Outcome Expectancy consisted of 9 items with factor loads ranging from .619 to .812 and STEM Career Awareness consisted of 4 items with factor loads ranging from.681 to .795.

Confirmatory Factor Analysis

As mentioned before, exploratory factor analysis of the ET-STEM Scale was conducted with Study Group 1, and confirmatory factor analysis was conducted with Study Group 2. Study Group 2 consisted of 213 elementary A confirmatory factor analysis using the structural equation model was conducted to determine the existing structure of the scale (see Figure 2).



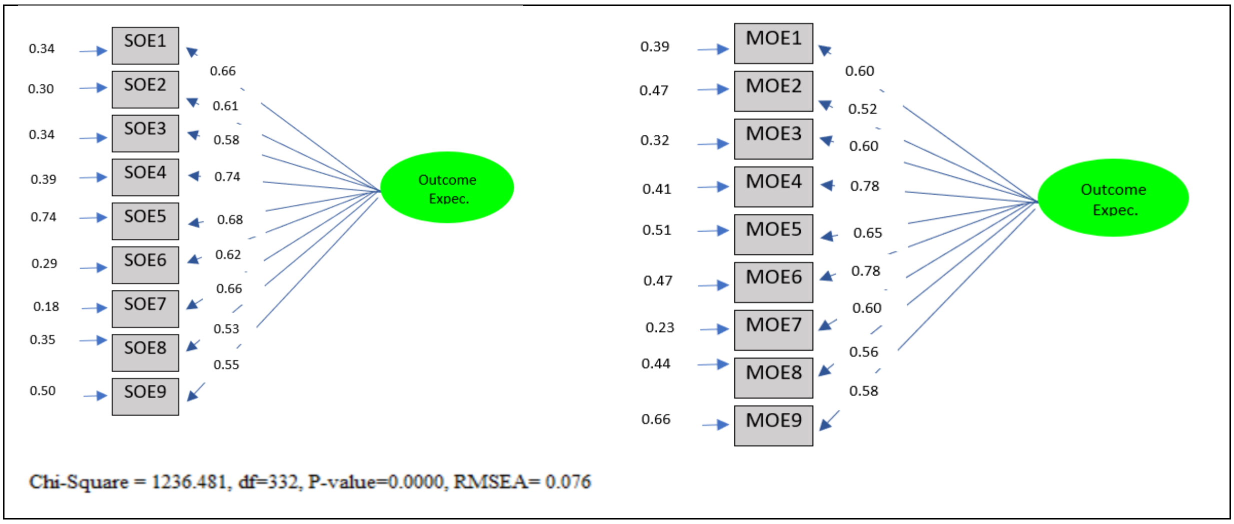


Figure 2. CFA result of ET-STEM scale

If the GFI and AGFI values are higher than 0.90 (Hooper, Coughlan, & Mullen, 2008; Sümer, 2000) and the RMR and RMSEA values are lower than 0.05 (Jöreskog & Sörbom, 1993; Sümer, 2000), the model-data fit is good. Nevertheless, if the GFI value is higher than 0.85, the AGFI is higher than 0.80, and the RMR and RMSEA values are lower than 0.080, model–data fit is acceptable (Anderson & Gerbing, 1984; Hu & Bentler, 1999; Sümer, 2000). The results of the confirmatory factor analysis for the ET-STEM Scale are shown in Table 6.

Table 6. Fit Indices of ET-STEM scale and acceptable fit indices values

Ki-kare	*p*-value	CFI	NFI	GFI	AGFI	IFI	SRMR	RMSEA
1236.481	$p < .05$	0.83	0.88	0.89	0.82	0.83	0.049	0.076

The results of the confirmatory factor analysis show that conformity between structural equation model and scale is high. Additionally, Chi-square value was found significant. The value of $\chi 2$ depends on the size of the sample, and when the size of the sample increases, it provides significant results. Briefly, when chi-square ($\chi 2$) is divided by the value of the degrees of freedom (*df*), it shows that the value is less than 5(χ^2(332) =1236.481); in other words, based on the results the model–data fit is high. In addition, if the CFI, NFI, AGFI values are (Hooper, Coughlan & Mullen, 2008; Sümer, 2000) above 0.80, it indicates that the model–data fit is high. Also, if RMSEA value is 0.076, it indicates that the model–data fit is high. According to confirmatory factor analysis it is determined that ET-STEM scale consists of nine subdimensions and model–data fit is high.

Discussion

In this study, the ET-STEM developed by Friday Institute for Educational Innovation (2012) is adapted to Turkish. Two different populations, a total of 526 elementary teachers were employed for validity and reliability analyses of the Turkish ET-STEM. Varimax analysis of the ET-STEM scale revealed a nine-factor structure, as in its original version (STEM Instruction, 21st Century Learning Attitudes, Science Teaching Efficacy and Beliefs, Mathematics Teaching Efficacy and Beliefs, Student Technology Use, Teacher Leadership Attitudes, Science Teaching Outcome Expectancy, Mathematics Teaching Outcome Expectancy and STEM Career Awareness, respectively). Total variance of these nine factors was 67.885%, and the Cronbach's Alpha value of the scale was 0.917. The Cronbach's Alpha value was calculated as.964 for STEM Instruction, .935 for 21st Century Learning Attitudes, .956 for Science Teaching Efficacy and Beliefs, .908 for Mathematics Teaching Efficacy and Beliefs, for Student Technology Use, .957 for Teacher Leadership Attitudes, .902 for Science Teaching Outcome Expectancy,.891 for Mathematics Teaching Outcome Expectancy, and .917 for STEM Career Awareness. Since adopted scale's Cronbach Alpha values greater than 0.80, Turkish version of the ET-STEM scale is reliable (Field, 2009; Kline, 1999). Also, these results are similar to the results Friday Institute for Educational Innovation found.

Furthermore, based on the confirmatory factor analysis results, the CFI, GFI, IFI, NFI, and AGFI values were above 0.80, indicating that model-data fit was high (Hooper, Coughlan & Mullen, 2008; Jöreskong & Sörbom, 1993).In addition, if the SRMR value is less than 0.05 and RMSEA values are less than 0.08, indicating that model–data fit was high (Hooper et al., 2008; Anderson & Gerbing, 1984; Hu & Bentler, 1999; Jöreskong & Sörbom, 1993). According to the confirmatory factor analysis results, model–data fit was high, and the Turkish version of ET-STEM Scale was found to have nine subdimensions. This scale was found to be valid and reliable based on the results of the exploratory and confirmatory factor analyses.

The Turkish version of ET- STEM scale will help teacher educators and policy makers to understand teachers' attitudes toward STEM. Second, it will guide school administrators while organizing professional development seminars. It will also give insight to researchers, policy makers, and administrators in the factors that are positively linked with elementary teachers' self-efficacy.

The related Turkish literature includes several different adopted scales and developed self-efficacy scales (Yıldırım, 2018; Çapa, Çakıroğlu & Sarıkaya, 2005; Bıkmaz, 2002; Taşkın & Hacıömeroğlu, 2010; Tepe, 2011) but these instruments mostly lack specificity in different subject areas. An elementary teacher may have high self-efficacy in teaching certain subject such as math, but not in another subject like science. Therefore, Turkish literature and researchers needs STEM content specific self-efficacy instrument.

Limitations of the Study and Suggestions

The Turkish version of ET-STEM scale will be used to measure elementary teachers' STEM-content knowledge, their technology use while teaching, 21st century learning skills, teacher' leadership attitudes, teachers' self-confidence and self-efficacy, and their STEM career awareness. Thus, this scale would be used in further researchers to measure these variables. Furthermore, this scale was originally designed to measure teacher self-efficacy in STEM in general. Other scales were developed and created to assess general aspects of self-efficacy. They are not specific for STEM.

A few of the limitations in the study may have implication on future studies. One limitation was the limit on responses created by the instrument (ET-STEM). Participants may have additional information they would like to share, but the instrument limited these responses. Using different techniques to collect a data would provide more insight into elementary teachers' perspectives. Another limitation is that possible selection bias of respondents. Respondents largely demonstrated high self-efficacy. It is possible that teachers with low self-efficacy did not respond the invitation to participate in the study. More invitations would be sent to bigger groups of elementary teachers in further researchers.

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Appendix-1.Teacher Efficacy and Attitudes toward STEM (T-STEM) Survey (Original Version of the Scale)

Elementary Teacher

Appropriate Use

The Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey is intended to measure changes in teachers' confidence and self-efficacy in STEM subject content and teaching, use of technology in the classroom, 21st century learning skills, leadership attitudes, and STEM career awareness. The survey is available to help program coordinators make decisions about possible improvements to their program. The Friday Institute grants you permission to use these instruments for educational, noncommercial purposes only. You may use an instrument as is, or modify it to suit your needs, but in either case you must credit its original source. By using this instrument, you agree to allow the Friday Institute to use the data collected for additional validity and reliability analysis. The Friday Institute will take appropriate measures to maintain the confidentiality of all data.

Recommended citation for this survey:

Friday Institute for Educational Innovation (2012). *Teacher Efficacy and Attitudes Toward STEM Survey-Elementary Teachers*, Raleigh, NC: Author.

The development of this survey was partially supported by the National Science Foundation under Grant No. 1038154 and by The Golden LEAF Foundation. The framework for part of this survey was developed from the following sources: Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teachers science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637. doi: 10.1002/sce.3730740605

DIRECTIONS:

For each of the following statements, please indicate the degree to which you agree or disagree. Even though some statements are very similar, please answer each statement. There are no "right" or "wrong" answers. The only correct responses are those that are true for you. Whenever possible, let the things that have happened to you help make your choice.

Science Teaching Efficacy and Beliefs

Directions: Please respond to these questions regarding your feelings about ***your own*** teaching.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I am continually improving my science teaching practice.	○	○	○	○	○
2. I know the steps necessary to teach science effectively.	○	○	○	○	○
3. I am confident that I can explain to students why science experiments work.	○	○	○	○	○
4. I am confident that I can teach science effectively.	○	○	○	○	○
5. I wonder if I have the necessary skills to teach science.	○	○	○	○	○
6. I understand science concepts well enough to be effective in teaching science.	○	○	○	○	○

7. Given a choice, I would invite a colleague to evaluate my science teaching.	○	○	○	○	○
8. I am confident that I can answer students' science questions.	○	○	○	○	○
9. When a student has difficulty understanding a science concept, I am confident that I know how to help the student understand it better.	○	○	○	○	○
10. When teaching science, I am confident enough to welcome student questions.	○	○	○	○	○
11. I know what to do to increase student interest in science.	○	○	○	○	○

Science Teaching Outcome Expectancy

Directions: The following questions ask about your feelings about teaching ***in general***. Please respond accordingly.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	○	○	○	○	○
2. The inadequacy of a student's science background can be overcome by good teaching.	○	○	○	○	○
3. When a student's learning in science is greater than expected, it is most often due to their teacher having found a more effective teaching approach.	○	○	○	○	○
4. The teacher is generally responsible for students' learning in science.	○	○	○	○	○
5. If students' learning in science is less than expected, it is most likely due to ineffective science teaching.	○	○	○	○	○
6. Students' learning in science is directly realted to their teacher's effectiveness in science teaching.	○	○	○	○	○
7. When a low achieving child progresses more than expected in science, it is usually due to extra attention given by the teacher.	○	○	○	○	○
8. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	○	○	○	○	○
9. Minimal student learning in science can generally be attributed to their teachers.	○	○	○	○	○

Mathematics Teaching Efficacy and Beliefs

Directions: Please respond to these questions regarding your feelings about ***your own*** teaching.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I am continually improving my mathematics teaching practice.	○	○	○	○	○
2. I know the steps necessary to teach mathematics effectively.	○	○	○	○	○
3. I am confident that I can explain to students why mathematics experiments work.	○	○	○	○	○
4. I am confident that I can teach mathematics effectively.	○	○	○	○	○
5. I wonder if I have the necessary skills to teach mathematics.	○	○	○	○	○
6. I understand mathematics concepts well enough to be effective in teaching mathematics.	○	○	○	○	○
7. Given a choice, I would invite a colleague to evaluate my mathematics teaching.	○	○	○	○	○
8. I am confident that I can answer students' mathematics questions.	○	○	○	○	○
9. When a student has difficulty understanding a mathematics concept, I am confident that I know how to help the student understand it better.	○	○	○	○	○
10. When teaching mathematics, I am confident enough to welcome student questions.	○	○	○	○	○
11. I know what to do to increase student interest in mathematics.	○	○	○	○	○

Mathematics Teaching Outcome Expectancy

The following questions ask about your feelings about teaching ***in general***. Please respond accordingly.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.	○	○	○	○	○
2. The inadequacy of a student's mathematics background can be overcome by good teaching.	○	○	○	○	○
3. When a student's learning in mathematics is greater than expected, it is most often due to their teacher having found a more effective teaching approach.	○	○	○	○	○
4. The teacher is generally responsible for students' learning in mathematics.	○	○	○	○	○

5. If students' learning in mathematics is less than expected, it is most likely due to ineffective mathematics teaching.	○	○	○	○	○
6. Students' learning in mathematics is directly realted to their teacher's effectiveness in mathematics teaching.	○	○	○	○	○
7. When a low achieving child progresses more than expected in mathematics, it is usually due to extra attention given by the teacher.	○	○	○	○	○
8. If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.	○	○	○	○	○
9. Minimal student learning in mathematics can generally be attributed to their teachers.	○	○	○	○	○

Student Technology Use

Please answer the following questions about how often students use technology in settings where you instruct students. If the question is not applicable to your situation, please select "Not Applicable."
During elementary STEM instructional meetings (e.g. class periods, after school activities, days of summer camp, etc.), how often do your students…

	Never	Occasionally	About half the time	Usually	Every time	Not Applicable
1. Use a variety of technologies, e.g. productivity, data visualization, research, and communication tools.	○	○	○	○	○	○
2. Use technology to communicate and collaborate with others, beyond the classroom.	○	○	○	○	○	○
3. Use technology to access online resources and information as a part of activities.	○	○	○	○	○	○
4. Use the same kinds of tools that professional researchers use, e.g. simulations, databases, satellite imagery.	○	○	○	○	○	○
5. Work on technology-enhanced projects that approach realworld applications of technology.	○	○	○	○	○	○
6. Use technology to help solve problems.	○	○	○	○	○	○
7. Use technology to support higher-order thinking, e.g. analysis, synthesis and evaluation of ideas and information.	○	○	○	○	○	○
8. Use technology to create new ideas and representations of information.	○	○	○	○	○	○

Elementary STEM Instruction

Please answer the following questions about how often students engage in the following tasks during your instructional time.

During elementary STEM instructional meetings (e.g. class periods, after school activities, days of summer camp, etc.), how often do your students…

	Never	Occasionally	About half the time	Usually	Every time
1. Develop problem-solving skills through investigations (e.g. scientific, design or theoretical investigations).	○	○	○	○	○
2. Work in small groups.	○	○	○	○	○
3. Make predictions that can be tested.	○	○	○	○	○
4. Make careful observations or measurements.	○	○	○	○	○
5. Use tools to gather data (e.g. calculators, computers, computer programs, scales, rulers, compasses, etc.).	○	○	○	○	○
6. Recognize patterns in data.	○	○	○	○	○
7. Create reasonable explanations of results of an experiment or investigation.	○	○	○	○	○
8. Choose the most appropriate methods to express results (e.g.drawings, models, charts, graphs, technical language, etc.).	○	○	○	○	○
9. Complete activities with a real-world context.	○	○	○	○	○
10. Engage in content-driven dialogue.	○	○	○	○	○
11. Reason abstractly.	○	○	○	○	○
12. Reason quantitatively.	○	○	○	○	○
13. Critique the reasoning of others.	○	○	○	○	○
14. Learn about careers related to the instructional content.	○	○	○	○	○

Appendix2. Öğretmenlerin STEM'e Yönelik Yeterlilikleri ve Tutumları (T-STEM) Ölçeği (Turkish Version Of The Scale)

Uygun Kullanım:

Öğretmenlerin STEM'e Yönelik Yeterlilikleri ve Tutumları (T-STEM) Ölçeği, öğretmenlerin STEM alanlarındaki konu alan bilgileri ve öğretimleri, sınıflarında teknoloji kullanımları, 21. yüzyıl öğrenme becerileri, liderlik davranışları, öğretmenlerin güven ve özyeterliliklerinde meydana gelecek değişimleri ve STEM alanlarıyla ilgili kariyer bilinçlerinin değişimini ölçmek amacıyla tasarlanmıştır. Anket, program koordinatörlerinin programlarındaki muhtemel geliştirmeler hakkında karar vermelerine yardımcı olması için hazırlanmıştır.

Anket formundaki sorulara vereceğiniz cevaplar yalnızca bu çalışma için kullanılacak olup, başkalarıyla paylaşılmayacaktır. Bu nedenle vereceğiniz samimi cevaplar gerçeği yansıtması açısından önemlidir.

Katılımınızdan ötürü çok teşekkür ederiz.

Dr. Bekir Yıldırım
Arş. Gör Emine Şahin

Branş : (…) Sınıf Öğretmenliği
Cinsiyet : (…) Bay
(…) Bayan
Deneyim : (…) 1-5 yıl arası
(…) 6-10 yıl arası
(…) 11-15 yıl arası
(…) 16-20 yıl arası
(…) 21yıl ve üzeri

TALİMATLAR:

Lütfen, aşağıdaki ifadelerin her biri için katılma veya katılmama derecenizi belirtiniz. Bazı ifadeler her ne kadar çok benzer olsa da lütfen her ifadeyi cevaplayınız. Ankette "Doğru" veya "Yanlış" cevap yoktur. Tek doğru cevap sizin için doğru olan cevaptır. Mümkün olduğunca, sizin başınıza gelen olayların, deneyimlerinizin seçiminizi yönlendirmesine izin verin.

Fen Öğretimi Yeterliği ve İnançlar

Talimat: ***Kendi öğretiminiz*** ile ilgili aşağıdaki soruları lütfen kendi duygu ve fikirlerinizi gözönünde bulundurarak yanıtlayınız.

	Kesinlikle katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle katılıyorum
1. Fen öğretimimi sürekli geliştiririm.					
2. Feni etkili öğretmek için gerekli aşamalarını bilirim.					
3. Bilimsel araştırmaların neden işe yaradıklarını öğrencilere açıklayabilme konusunda kendime güveniyorum.					
4. Fen dersini etkili bir şekilde öğretebildiğim konusunda kendime güveniyorum					
5.Feni etkili bir şekilde öğretebileceğim konusunda kendime güveniyorum.					
6.Fen kavramlarını fen derslerinde etkili şekilde öğretebilecek kadar iyi bilir ve anlarım.					

7.Eğer fırsatım olsaydı meslektaşımı sınıfıma fen öğretimimi değerlendirmesi için davet ederdim.					
8.Öğrencilerin fenle ilgili tüm sorularını cevaplayabileğim konusunda kendime güveniyorum.					
9.Bir öğrenci, bir fen kavramını anlamakta zorluk çektiğinde, o öğrencinin kavramı daha iyi anlayabilmesi için neler yapmam gerektiğini bildiğimden eminim.					
10.Fen öğretirken öğrencilerin soru sormasını hoş karşılayacağım konusunda kendime güvenirim.					
11.Öğrencilerin fene karşı olan ilgilerini artırmak için ne yapılması gerektiğini bilirim.					

Fen Öğretiminde Sonuç Beklentileri

Talimat: Aşağıdaki sorularda sizin öğretimle ilgili ***genel*** düşünceleriniz sorulmaktadır. Lütfen uygun bir şekilde cevaplayınız.

	Kesinlikle katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle katılıyorum
1. Bir öğrenci fen dersinde ortalamanın üzerinde başarı gösterdiğinde, bu çoğunlukla öğretmenin gösterdiği fazla çabanın bir sonucudur.					
2. İyi bir öğretim ile bir öğrencinin fen alanlarındaki yetersizliğinin önüne geçilebilir.					
3. Bir öğrencinin fendeki öğrenimi beklenilenden daha iyi olduğunda, bu çoğunlukla öğretmenin daha etkili bir öğretim yaklaşımı kullanmasının bir sonucudur.					
4. Öğrencinin fen öğreniminden genellikle öğretmen sorumludur.					
5. Öğrencinin fen öğrenimi beklenilenden düşük ise, bu muhtemelen fen öğretiminin etkin bir şekilde yapılamamasından kaynaklanıyordur.					
6. Öğrencinin fen öğrenimi doğrudan öğretmenin fen öğretiminde etkili oluşuyla alakalıdır.					
7. Düşük seviyeli bir öğrenci fende beklenenden daha yüksek bir başarı gösterirse bu genellikle öğretmen tarafından gösterilen fazla ilginin bir sonucudur.					
8. Eğer ebeveynler çocuklarının okulda fene olan ilgilerinin arttığı çıkarımında bulunurlarsa, bu ilgi artışı muhtemelen çocuğun öğretmeninin performansının bir sonucudur.					
9. Öğrencilerin minimum düzeyde fen öğrenmeleri genellikle öğretmene bağlanır.					

Matematik Öğretimi Yeterliği ve İnançlar

Talimat: Aşağıda kendi öğretiminizle ilgili soruları lütfen duygularınızıda göz önünde bulundurarak cevaplayınız.

	Kesinlikle katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle katılıyorum
1.Matematik öğretimimi sürekli geliştiririm.					
2.Matematiği etkili öğretmek için gerekli aşamalarını bilirim.					
3.Matematiksel araştırmaların neden işe yaradıklarını öğrencilere açıklayabilme konusunda kendime güveniyorum.					
4.Matematik dersini etkili bir şekilde öğretebildiğim konusunda kendime güveniyorum.					
5.Matematik öğretimiyle ilgili gerekli becerilere sahip olup olmadığımı merak ederim.					
6.Matematiksel kavramları matematiği etkili bir şekilde öğretecek kadar bilirim.					
7. Eğer fırsatım olsaydı meslektaşımı sınıfıma matematik öğretimimi değerlendirmesi için davet ederdim.					
8.Öğrencilerin matematikle ilgili sorularını cevaplayabileğim konusunda kendime güveniyorum.					
9.Bir öğrenci, bir matematik kavramını anlamakta zorluk çektiğinde, o öğrencinin kavramı daha iyi anlayabilmesi için neler yapmam gerektiğini bildiğimden eminim.					
10.Matematik öğretirken öğrencilerin soru sormasını hoş karşılayacağım konusunda kendime güvenirim					
11.Öğrencilerin matematiğe karşı olan ilgilerini artırmak için ne yapılması gerektiğini bilirim.					

Matematik Öğretiminde Sonuç Beklentileri
Talimat: Aşağıdaki sorular sizin öğretimle ilgili ***genel*** düşüncelerinizi sormaktadır. Lütfen uygun şekilde cevaplayınız.

	Kesinlikle katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle katılıyorum
1. Bir öğrenci matematikte ortalamanın üzerinde başarı gösterdiğinde, bu çoğunlukla öğretmenin gösterdiği fazla çabanın bir sonucudur.					
2.İyi bir öğretim ile bir öğrencinin matematikle ilgili yetersizliğinin önüne geçilebilir.					
3.Bir öğrencinin matematikteki öğrenimi beklenilenden daha iyi olduğunda, bu çoğunlukla öğretmenin daha etkili bir öğretim yaklaşımı kullanmasının bir sonucudur.					
4.Öğrencinin matematik öğreniminden genellikle öğretmen sorumludur.					
5.Öğrencinin matematik öğrenimi beklenilenden düşük ise, bu muhtemelen matematik öğretiminin etkin bir şekilde yapılamamasından kaynaklanıyordur.					
6.Öğrencinin matematik öğrenimi doğrudan öğretmenin matematik öğretiminde etkili oluşuyla alakalıdır.					
7.Düşük seviyeli bir öğrenci matematikte beklenenden daha yüksek bir başarı gösterirse bu genellikle öğretmen tarafından gösterilen fazla ilginin bir sonucudur.					

8.Eğer ebeveynler çocuklarının okulda matematiğe olan ilgilerinin arttığı çıkarımında bulunurlarsa, bu ilgi artışı muhtemelen çocuğun öğretmeninin performansının bir sonucudur.					
9.Öğrencilerin minimum düzeyde matematik öğrenmeleri genellikle öğretmene bağlanır					

Öğrencilerin Teknoloji Kullanımı

Talimat: Sizin öğretim yaptığınız yerlerde öğrencilerinizin teknolojiyi ne kadar sıklıkla kullandığıyla alakalı aşağıda verilmiş olan soruları lütfen cevaplayınız. Eğer soru sizin durumunuz için geçerli değil ise lütfen 'Geçerli Değil' seçeneğini işaretleyiniz.

STEM öğretimi boyunca (örneğin ders zamanları, okul sonrası aktiviteler, yaz kampı vb.) ne sıklıkla öğrencilerin….

	Asla	Nadiren	Bazen	Genellikle	Her zaman	Geçerli Değil
1. Farklı teknolojileri kullanır (örn. yaratıcılık, veri görselleştirme, araştırma yapmak ve iletişim araçları)						
2. Sınıf ortamı dışındada diğerleriyle haberleşmek ve birlikte çalışmak için teknolojiyi kullanır.						
3. Online kaynaklara ve bilgiye ulaşmak için teknolojiyi etkinliklerin bir parçası olarak kullanır.						
4. Uzman araştırmacıların da kullandığı tarazda araçları kullanır (örn. simülasyonlar, veri tabanları, uydu görüntüleri).						
5. Teknolojinin gerçek yaşam içerisindeki kullanımını ele alan teknoloji-destekli projeler üzerine çalışır.						
6. Teknolojiyi problemlerin çözümüne çözmede yardımcı olması için kullanır.						
7. Üst düzey düşünmeyi desteklemek için teknolojiyi kullanır (örn. analiz, sentez, fikir ve bilgileri değerlendirme).						
8. Yeni fikirler oluşturmak ve bilginin gösterimi için teknolojiyi kullanır.						

STEM Öğretimi

Talimat: Sizin öğretim yaptığınız sırada öğrencilerinizin etkinliklere ne kadar sıklıkla katılım gösterdiği ile ilgili aşağıdaki soruları lütfen cevaplayınız.

STEM öğretimi boyunca (örneğin ders zamanları, okul sonrası aktiviteler, yaz kampı vb.) ne sıklıkla öğrencilerin….

	Asla	Nadiren	Bazen	Genellikle	Her zaman
1. Araştırma yoluyla problem çözme becerilerini geliştirir (örn. Bilimsel, tasarım, teorik araştırmalar).					
2. Küçük gruplar halinde çalışır.					
3. Test edilebilir tahminlerde bulunur.					
4. Dikkatli ölçümler veya gözlemlemeler yapar.					
5. Veri toplamak için araçlar kullanır (örn. hesap makineleri, bilgisayarlar, bilgisayar programları, ölçekler, cetveller, pusulalar, vb.)					
6. Verilerdeki desenleri farkeder.					
7. Bir deney veya araştırmanın sonuçlarından yola çıkarak mantıklı açıklamalar oluşturur.					

8. Sonuçları ifade etmek için en uygun yöntemleri seçer (örn. çizimler, modeller, grafikler, tablolar, teknik dil, vb.)					
9. Gündelik hayat içinden verilen etkinlikleri tamamlar.					
10. İçerik odaklı diyaloglar içerisindedir.					
11. Soyut düşünür.					
12. Nicel düşünür.					
13. Diğerlerinin düşüncelerini eleştirir.					
14. Öğretilen içerikle ile ilgili kariyer alanlarını öğrenir.					

21. Yüzyıl Öğrenim Tutumları

Talimat: Lütfen öğrenimle ilgili ***genel*** fikirlerinizi içeren aşağıdaki soruları cevaplayınız.

	Kesinlikle katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle katılıyorum
1. Bence öğrencilerin diğerlerinin hedeflerine ulaşmasını sağlayacağı öğretim ortamlarında olmaları önemlidir.					
2. Bence öğrencilerin diğer öğrencilerin ellerinden gelenin en iyisini yapmalarını sağlayabilecekleri öğretim ortamlarında olmaları önemlidir.					
3. Bence öğrencilerin yüksek kaliteli, nitelikli çalışmalar üreteceği öğretim ortamlarında olmaları önemlidir.					
4. Bence öğrencilerin akranları arasındaki farklılıklara saygı duyabileceklerini sağlayan öğretim ortamında olmaları önemlidir.					
5. Bence öğrencilerin akranlarına yardım edebilecekleri öğretim ortamında olmaları önemlidir.					
6. Bence öğrencilerin karar verirken başkalarınında fikirlerinin alındığı öğretim ortamında olmaları önemlidir.					
7. Bence öğrencilerin işler planlandığı gibi gitmediğinde değişimler yapılabilecekleri öğretim ortamında olmaları önemlidir.					
8. Bence öğrencilerin kendi hedeflerini belirledikleri öğretim ortamında olmaları önemlidir.					
9. Bence öğrencilerin kendi başlarına çalışırken zamanı planlayabilecekleri öğretim ortamında olmaları önemlidir.					
10. Bence öğrencilerin birçok görev arasından hangisinin önce yapılacağını seçebileceği öğretim ortamında olmasının önemlidir.					
11. Bence öğrencilerin farklı sosyal çevrelerden, deneyimlerden gelen öğrencilerle birlikte uyum içinde çalışabilecekleri öğretim ortamında olmaları önemlidir.					

Öğretmen Liderlik Tutumu

Talimat:
Lütfen öğretmen liderliği ile ilgili ***genel*** düşünceleriniz hakkındaki aşağıdaki soruları cevaplayınız.

	Kesinlikle katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle katılıyorum
1. Öğretmenlerin tüm öğrencilerin öğrenmeleri için sorumluluk almalarının önemli olduğunu düşünüyorum.					

2. Öğretmenlerin vizyonlarını öğrencilere anlatmasının önemli olduğunu düşünüyorum.					
3. Öğretmenlerin yıl boyunca çeşitli ölçme değerlendirme yaklaşımlarını kullanarak öğrenci gelişimini değerlendirmesinin önemli olduğunu düşünüyorum.					
4. Öğretmenlerin farklı verileri kullanarak organizasyon yapmalarının, planlamalarının ve hedefler belirlemelerinin önemli olduğunu düşünüyorum.					
5. Öğretmenlerin güvenli ve düzenli bir ortam sağlamasının önemli olduğunu düşünüyorum.					
6. Öğretmenlerin öğrencileri teşvik etmesinin önemli olduğunu düşünüyorum.					

STEM Kariyer Farkındalığı

Talimat: Lütfen aşağıdaki ifadelere ne kadar katılıp katılmadığınız ile ilgili aşağıdaki soruları cevaplayınız.

	Kesinlikle katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle katılıyorum
1. Mevcut STEM mesleklerini biliyorum.					
2. STEM meslekleri hakkında daha fazla bilgi sahibi olmak için nereye gitmem gerektiğini biliyorum.					
3. STEM mesleklerini öğrencilere öğretmek istediğimde hangi kaynaklara bakacağımı biliyorum.					
4. STEM meslekleriyle ilgili bilgi edinmek isteyen öğrencileri veya ebeveynleri nereye yönlendireceğimi biliyorum.					

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A Thematic Review of Tablet-Based Science Education Studies

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Abstract

The use of tablet in schools has been getting importance in a parallel with any change in educational policies. It can be said that the use of tablets was investigated on the variables such as success and attitude in the literature and the number of studies increased related to the applications that can be used in tablets. In this context, it was considered that analyzing the studies conducted in the field of science education, which was one of the courses where tablet use was recommended, will be important for both teacher - prospective teacher candidates who were practitioner and literature. The aim of this study was to thematically examine and analyze tablet-based science education studies. 25 articles were exposed to this thematic review via the matrix developed by Ormanci et al. (2015). The matrix consists of two parts-general properties (type of journals, years, etc.) and content (rationales, aims, research methods, etc.). The results indicated rationales of related studies were very limited. Further, there were experimental studies examining the effects of tablet-based science education on student success and performance. None of previous studies examined the effects of tablet-based science education on the participants' skills, which should be investigated in future studies.

Introduction

Technological advancements as well as changes in the education policies of countries in parallel to the advancements have led the countries to use various technological devices such as tablets or smart boards in their education programs. As stated by Inagaki et al. (2011), educational reforms carried out via information and communication technologies are the priorities of governments all over the world. It is known that computers have become a part of daily lives of both adults and children in many countries (Straker, Coleman, Skoss, Maslen, Burgess-Limerick and Pollock, 2008). The technological advancements which hold an important place among the recent developments in the world have affected all areas of life including education and teaching (Ilyasoglu and Aydin, 2015). It can be stated that tablets are among the devices that have recently gained importance along with technological advancements in addition to computers. As stated by Amirnudin and Sulaiman (2013), tablet technology has become one of the most rapidly advancing technologies in the world. The portability of the tablets as well as the ease of note taking have resulted in increased attention towards them in various sectors such as health, construction, government and education (El-Gayar, Moran and Hawkes, 2011). In this regard, tablets have gained rapid popularity and used as a strong tool of education in classrooms (Hocanın and Iscioglu, 2014). Cuhadar (2014) stated that tablet use has gained popularity at university level. In addition, it can be stated that the importance given to tablets has been increasing in all levels of education and that tablet use gained popularity. It can be propounded that the popularity of tablets are since the properties of tablets are quite suited to educational activities (Gill, 2007). Since tablets have different functions that enrich the educational environments, they make positive impacts on student learning (Varank, Yeni and Gecu, 2014).

Tablets are functional laptop computers which include a touch screen for data input (Romney, 2011). In other words, they are laptop computers including properties that enable direct input to the screen for creating electronic documents against to traditional computer applications allowing the use of pens via stylus with simulated paper properties (Enriquez, 2009; 2010). In this regard, tablets are becoming more practical in comparison with computers due to their mobility (portability) and digital properties (Gubacs-Collins and Juniu, 2009). Different than traditional laptop computers, tablets are equipped with a screen digitizer that enables users to write directly on the screen as well as a stylus pen (Cao, 2014; Galligan, Loch, McDonald and Taylor, 2010; Ozok, Benson, Chakraborty and Norcio, 2008; Reboli, 2007). In addition, tablets have additional functionalities that provide a digital link to the users for creating direct information on the screen (Moore, Utschig, Haas, Klein, Yoder, Zhang et al., 2008). The laptop computers generally have a keyboard and a mouse whereas the primary input device has been designed as a pen for tablets (Chambers, Chidanandan, DeVasher, Merkle, Minster, Mitra-Kirtley et al., 2006). As it can be understood, tablets are connection free functional mobile computers (Park and del Pobil, 2013). In this regard, tablets provide various additional choices such as mobility, direct interaction with the screen which make them more effective than computers and leading to their increased importance in classroom use.

There are mainly two different methods for the use of tablets in classrooms. They are interactive mode and non-interactive mode (Chen and Sager, 2011). Similarly, Sheehy, Kukulska-Hulme, Twining, Evans, Cook and Jelfs (2005) purposed in their studies that some students use tablets to access video, web links and worksheets whereas others use tablets as data projectors instead of smart boards. In this regard, it can be stated that many applications have been developed for interactive and non-interactive tablet use in teaching environments. Some of these applications can be used in all courses whereas others are directly field related applications. As affirmed by Tran, Ma, Sharma and Liu (2006), the current Tablet PC tools provided by Microsoft are Input Panel, Office OneNote, Windows Journal, StickyNotes and EducationPack in addition to Timesheet Tools such as Business Calendar, Financial/Budget, Time Trackeretc. These applications can be used in tablets not only to increase efficiency but also help teachers and students in organizing ideas, concepts and processes during project creation as well as in assigning tasks and time management (Schnackenberg, 2013). Both clikers and Classroom Presenter are among important classroom advancements (Roschelle, Tatar, Chaudhury, Dimitriadis, Patton and DiGiano, 2007). There are many other applications and researchers carry out trials with these applications to examine their effectiveness on classroom use.

When tablet related studies are examined, it was asserted that many benefits observed for both students and teachers for classroom use. Lim (2011) states that texts prepared directly on digital screens of the tablets are much more efficient in comparison with writing on the board and preparing power point slides. In addition, digital ink takes the place of pen and paper in education to enable teachers completing and sending back hand written feedback digitally (Li and Akahori, 2007). In this regard, it can be stated that increase in teacher efficiency when acquiring student evaluation data, authentic learning environment, creation of more active environments and internet access are among the benefits of tablets (Nye, 2010). In addition, mobile devices provide opportunities for fast data acquisition, organization and data exchange as put forth by Avraamidou (2008). Tablets encourage teaching to be adapted for applications and participation (Roschelle et al., 2007) while attracting the students to the course by using digital ink as teaching material (Gorgievski, Stroud, Truxaw and DeFranco, 2005). It can also be stated that tablet use has various benefits for courses as well. For example, analysis and solution of problems that require mathematical formulations, diagrams and sketches make tablets more suited in comparison with laptop computers (Enriquez, 2009). Tablets provide students with an environment for text, graphics, sound, video, picture, animation and simulation (Tekbiyik and Akdeniz, 2010). As can be understood, it can be stated that the use of tablets in classes has many benefits for both students and teachers.

The literature review reveals that there are studies on the use of tablets in education-teaching environments. Avraamidou (2008) carried out a literature review study on expectations regarding the use of mobile technologies in science education, whereas Cao (2014) carried out a literature review study on the use of tablet technology to create an interactive classroom environment. In addition, Cicchino and Mirliss (2004) carried out a literature review study on tablets as a teaching tool whereas Schnackenberg (2013) carried out a literature review study related with education and tablet technology. Willis and Miertschin (2004) carried out a study on the use of Tablet PC as a teaching tool in which they shared their experiences at the Faculty in the College of Technology at the University of Houston. Ozkale and Koc (2014) carried out a literature review study related with the use of tablet computers in teaching environments. When these studies are examined, it is understood that in general they contain theoretical information on tablet use and application areas. In these studies, the author gives the information about tablets which is not research findings. They define the tablet application, tablets and education, tablets in classroom etc. Therefore, there can be said that there is no article includes research results on the use of tablets in science education. In the literature Sheehy et al. (2005) emphasized in their study that the key findings of the review of projects in which Tablet PC's are used as well as the literature review. When this study is examined, it can be said that a limited number of articles were included in the study. In addition, this study was carried out in 2005 and new and current studies are needed in the literature. It can also be added that there are limited number of studies which contains a detailed analysis. It can also be added that no study was found which contains a detailed examination and analysis of the studies carried out in this field. In this regard, it can be stated that there is a need for a study which reviews the research articles on tablet use in science education.

It can be stated that the review and analysis of articles are important which published at the national and international levels, proceedings and theses on tablets. Because, the study carried out is important for presenting the current status to the researchers, giving a direction regarding shortcomings and providing new ideas. It can be stated that review studies which are related with approaches or tools that have started to gain importance recently as well as those that are open to research in the field are especially important. In parallel with the limited number of relevant studies in international literature, studies and applications carried out in Turkey on educational tablet use is still at a beginning stage (Cuhadar, 2014). In this regard, it is thought that carrying out a review and analysis on the studies related with tablet use in science education will be important for researchers, teachers, curriculum developers and policy makers.

The aim of the study was to carry out an analysis of the studies on tablet use in science education regarding general features, rationales, aims, research methods, samples, results and suggestions. The focus questions for our review of the literature are as follows:

1. What are the rationales behind the use of tablets in science education?
2. What are the aims of the studies regarding the use of tablets in science education?
3. What research methods, samples, instruments, applications and concepts are used in the studies regarding the use of tablets in science education?
4. What are the results of the studies regarding of tablets in science education?
5. What are the suggestions for researchers, teachers, curriculum developers and policy makers regarding the use of tablets in science education?

Method

In this study, a thematic review of the studies was presented on tablet use in science education. Literature review is the examination of visual and auditory pieces such as articles, documents, maps, pictures, photographs on the related topic (Cepni, 2014). Whereas, the thematic review should emphasize how learning and teaching will develop as well as questions on the practicality of the suggestions made and the accomplishments (Ultay and Calik, 2012). Thematic matrix should be used to define every study, emphasize general trends, explain similarities and differences and indicate the unique features of each study (Calik, Ayas and Ebenezer, 2005; Kurnaz and Calik, 2009).

Table 1. Distribution of studies by types

Name	Types	f	Types	f	f
Computers & Education	Journal	2	International (SSCI/ SCI)	4	
Advances in Physiology Education	Journal	1			
Journal of Chemical Education	Journal	1			
Mevlana International Journal of Education	Journal	2			
Cumhuriyet International Journal of Education	Journal	1			
Interactive Technology and Smart Education	Journal	1			
Kamla-Raj: International Journal of Educational Sciences	Journal	1			13
Mustafa Kemal University Journal of Social Sciences Institute	Journal	1	International	9	
Journal of College Science Teaching	Journal	1			
Turkish Studies-International Periodical for the Languages Literature and History of Turkish or Turkic	Journal	1			
Physics Education	Journal	1			
World Conference on Educational Multimedia, Hypermedia and Telecommunications	Conference	2	10 years and more than 10 years	2	
International Conference on Computer Supported Education	Conference	2			
International Conference New Perspective in Science Education	Conference	1			9
International Technology, Education and Development Conference	Conference	1	Less than 10 years	7	
IEEE International Conference	Conference	1			
AIP Conference	Conference	1			
Frontiers in Education Conference	Conference	1			
Doctoral Thesis	Thesis	1			
Master Thesis	Thesis	1	Thesis/ Book	3	3
Book	Book	1			
Total		25		25	25

Sample and Data Collection

Taylor & Francis, Springer, Scopus, Science Direct, EBSCO, JSTOR, Web of Science, Wiley Online Library, Google Academy databases were examined within the scope of the study. In addition, the magazines were also reviewed including in the social sciences citation index (SSCI) which publish studies on technology or computer use. The studies related with tablet use in science education were tried to be downloaded as a result of the performed review work. Some studies could not be reached despite all efforts and some studies could not be obtained fully but only their abstracts. In this regard, this issue that occurred during database review can be specified as a limitation of the study.

The keywords "tablet/s" "tablet pc/s" and "science education", "science curriculum" or "science classroom" were entered into the database when reviewing the studies on tablet use in science education. 25 studies were found on tablet use in science education and these articles have been marked with an asterix (*) in the references section. Table 1 showed the frequency values for the studies carried out on tablet use in science education. 13 studies published in international journals such as Computers & Education, Advances in Physiology Education, Journal of Chemical Education, Mevlana International Journal of Education. In addition, nine studies presented in conferences whereas three studies published as part of a thesis or a book section.

Table 2. Frequencies of studies by years of studies

Years of Studies	SSCI/ SCI f	International f	Conference f	Thesis/Books f	Total f
2014	2	3	1	-	6
2013	1	3	3	2	9
2012	1	2	1	-	4
2011	-	1	-	-	1
2010	-	-	1	-	1
2009	-	-	-	1	1
2008	-	1	1	-	2
2007	-	-	1	-	1
Total	4	10	8	3	25

Table 2 showed the frequency values for the distribution of studies by year. When we looked at Table 2, it was observed that one study each on tablet use in science education had been carried out in 2007, 2009, 2010 and 2011 whereas two studies had been carried out in 2008. It was observed that the number of studies was four in 2012, nine with a significant increase in 2013 and six in 2014.

Table 3. Frequencies of studies by number of authors

Number of Authors	SSCI/ SCI f	International f	Conference f	Thesis/Books f	Total f
1	1	-	-	2	3
2	-	4	2	1	7
3	1	4	1	-	6
4	1	1	1	-	3
5	-	-	4	-	4
6	1	-	-	-	1
8	-	-	1	-	1
Total	4	9	9	3	25

Table 3 showed the information related with the number of authors and Table 4 showed the information related with the frequencies of authors by nationality. When Table 3 was examined, it was observed that three studies had either one or four authors, seven studies had two authors and seven studies had three authors.

When Table 4 was examined, of the studies carried out on tablet use in science education seven studies had been carried out in Turkey, seven studies in the United States, three studies in Canada, two studies in the United Kingdom and two studies is Japan. Almost all the studies carried out by Turkish citizens had published in international journals.

Table 4. Frequencies of studies by authors nationality

Authors Nationality	SSCI/ SCI f	International f	Conference f	Thesis f	Total f
Turkey	-	6	1	-	7
United States	3	-	3	1	7
Canada	1	1	1	-	3
United Kingdom	1	1	-	-	2
Japan	-	-	2	-	2
The Netherlands	-	-	1	-	1
Italy	-	-	1	-	1
Sweden	-	-	-	1	1
Indiana	-	-	-	1	1
India	-	-	1	-	1
Finland	-	1	-	-	1
Total	5	9	10	3	27

Data Analysis

In this study, the matrix was used for the analysis of the studies. In this regard, the matrix developed by Ormanci, Cepni, Deveci and Aydin (2015) was used to analyze the studies related with tablet use in science education. The matrix used in this study includes two fundamental themes such as general features and content features. General features include types of journals, years of studies and demographic properties (number of authors and author nationality). These features used to portray the studies under investigation. Content features include rationales, aims, research methods, samples, data collections, results and suggestions. In addition, two additions were made to the method section of the matrix in this study to explain in more detail the tablet applications and the studies on scientific concepts. The final version of the matrix is given in Table 5.

Table 5. Matrix for a thematic review of the use if tablet PCs in science education

Themes	Sub-Themes	Explanations
General Features	Type of Studies	Place and group of the publication (article, congress, etc.)
	Years	Year of the publication
	Demographic Properties (Number of Authors)	Number of authors
	Demographic Properties (Author Nationality)	Nationality of the author
Content Features	Rationales	Rationale of the study
	Aims	Main aim of the study
	Research Methods	Qualitative (case study, action research, etc.), quantitative (descriptive, survey, etc.) and others (mix methods, etc.)
	Samples	Sample of the study (teacher, teacher candidate, student, etc.) and sample numbers (0-10, 11-30, 31-100, 101-200, 201 and up)
	Data Collections	Data collection of the study (interviews, observations, survey etc.)
	Applications	Application of the study (classroom presenter, DyKnow, etc.)
	Science Concepts	The concept which is researched (electricity, gain etc.)
	Results	Main result of the study
	Suggestions	Main suggestion of the study

The acquired data were analyzed via descriptive statistical methods (percentage and frequency) and content analysis method. Descriptive analysis was generally used for the general properties of the matrix whereas content analysis was used for the content properties of the matrix. Data acquired from the studies were first transformed into codes during content analysis after which suitable codes were combined to create themes. Frequency and % values were calculated for the generated codes and themes. In the study, the studies were examined by two researchers in order to ensure the validity and reliability of the study. The unstable places in the analysis were decided by two researchers.

Results

This section of the study contains results regarding content features (rationales, aims, research methods, samples, data collections, applications, science concepts, results and suggestions.).

1. What are the rationales behind the use of tablets in science education?

The frequency and percentage distribution values regarding the rationales of studies on tablet use in science education were showed in Table 6.

Table 6. Frequencies of studies by rationales

Theme	Sub-Theme	Rationale Code	f	%	f	%	f	%
Science related	Shortcoming in the Field	Low number of studies on tablets	1	5.3	3	15.8	8	42.1
		The fact that its effect on learning process cannot be determined even though it is an education tool	1	5.3				
		The need for studies on the effects of tablets on learning attitudes	1	5.3				
	Material Change	Lack of material related with teacher education for tablets	1	5.3	5	26.3		
		The fact that computer simulations have a significant space in teaching concepts	1	5.3				
		Difficulties in making selections due to the large number of applications in the field	1	5.3				
		Importance of the use of computer aided visual material	1	5.3				
		Necessity of new technologies to establish classes for research/questioning	1	5.3				
General	Shortcoming in the Field	Low number of studies on tablets	1	5.3	4	21.1	11	57.9
		Necessity of integrating tablets with new learning methods	1	5.3				
		Importance of student opinions about the topic	1	5.3				
		Importance of the opinions of teachers as the appliers	1	5.3				
	Innovation	Increased use of tablets in education	1	5.3	4	21.1		
		Increase of tablet use among students	1	5.3				
		Increase of the use of digital books	1	5.3				
		Increase of technology in the classrooms	1	5.3				
	Positive Effects on Teaching Environment	The fact that tablets provide an increase in student learning	1	5.3	3	15.8		
		The fact that its use related with student activity and learning positivity increases	1	5.3				
		The positive effects of new technologies on students, teachers and the classroom environment	1	5.3				
	Total*		19	100.0	19	100.0	19	100.0

*Since some studies did not give rationales, the total number is not equal to the number of articles.

Table 6 showed the rationales for studies related with tablet use in science education and the rationales were classified under two main themes with respect to whether a relationship with science established or not. Rationales related with science were classified under shortcomings in the field and material change, whereas general rationales were classified under sub-themes of shortcomings in the field, innovation and the positive effect on innovation and learning environment. It was asserted that %5.3 of the studies carried out due to the fact that the number of studies on tablets is low with whereas the percentage for the lack of materials related with teacher material on tablets was %5.3, the percentage for the increased popularity of tablet use in education was %5.3, and the percentage for the increase in student learning caused by tablet use was %5.3.

2. What are the aims of the studies regarding the use of tablets in science education?

The frequency and percentage values for the aims of the studies carried out in science education using tablets were showed in Table 7.

Table 7**.** Frequencies of studies by aims

	Aims				
Theme	Code	f	%	f	%
Effectiveness	Examining the effect on the student	3	9.8	12	38.7
	Examining the effect on student performance	2	6.5		
	Examining the effectiveness of tablet material	2	6.5		
	Examining the effect on teachers	1	3.2		
	Examining the effect on learning gains	1	3.2		
	Examining the effect on learning outputs	1	3.2		
	Examining the effect on student success	1	3.2		
	Examining the effect on student attitude	1	3.2		
Case report	Taking teacher opinions on tablets	2	6.5	7	22.6
	Taking student opinions on tablets	1	3.2		
	Examining experiences related with tablet use	1	3.2		
	Examining tablet use in drawing and discussion environments	1	3.2		
	Examining the use to archive student homework	1	3.2		
	Examining the use to attract the attention of students	1	3.2		
Material Development	Developing tablet applications	4	12.9	7	22.6
	Developing a rubric related with mobile science applications	1	3.2		
	Developing course books that are suited to tablet use	1	3.2		
	Developing tablet related materials	1	3.2		
Attitude	Examining the attitudes of students towards technology in tablet applications	2	6.5	5	16.1
	Developing an attitude scale for tablet applications	1	3.2		
	Examining the attitudes of parents towards tablet applications	1	3.2		
	Examining the attitudes of teachers towards tablet applications	1	3.2		
Total*		31	100.0	31	100.0

*Since some studies had more than aim, the total number is not equal to the number of articles.

When Table 7 was examined, it can be observed that the relevant studies was collected under the themes of status determination, material development and related with attitude. It is observed that %9.8 of the studies examine the effects on students, %6.5 of the studies examine the effects on student performance and %6.5 of the studies examine the effectiveness of the tablet material. In addition, it is observed that %6.5 of the studies in the literature examine the attitudes of students towards technology in tablet applications and %6.5 of the studies include attitudes of teachers regarding tablets. In addition, %12.9 of the studies in literature aims to develop tablet applications.

3. What research methods, samples, instruments and applications are used in the studies regarding the use of tablets in science education?

The frequency and percentage values of the methods used in studies regarding the use of tablets in science education were showed in Table 8.

Table 8. Frequencies of studies by methods

Methods	SSCI/ SCI		International		Conference		Thesis/ Books		Total*	
	f	%	f	%	f	%	f	%	f	%
Experimental/empirical method	1	4.5	2	9.1	3	13.6	2	9.1	8	36.4
Descriptive survey	-	-	3	13.6	-	-	-	-	3	13.6
Case study	-	-	-	-	3	13.6	-	-	3	13.6
Survey method	-	-	2	9.1	-	-	-	-	2	9.1
Mixed method	1	4.5	-	-	-	-	-	-	1	4.5
Controlled study	1	4.5	-	-	-	-	-	-	1	4.5
Comparison method	-	-	1	4.5	-	-	-	-	1	4.5
Improving apps	-	-	-	-	1	4.5	-	-	1	4.5
Modified Delphi study	-	-	-	-	1	4.5	-	-	1	4.5
Scale development	-	-	1	4.5	-	-	-	-	1	4.5
Total	3	13.6	9	40.9	8	36.4	2	9.1	22	100.0

*Since some studies did not included methods, the total number is not equal to the number of articles.

When Table 8 was examined, it can be observed that %36.4 of the studies used the frequently experimental/empirical method, % 13.6 of the studies used the descriptive survey or the case study method and that %9.1 of the studies used the survey method. It is understood that journals within the scope of SSCI/SCI used experimental/empirical method, mixed method or controlled study, whereas international journals used experimental method, descriptive survey, survey method. In addition, it was determined that some studies had not specified the used methods. The frequency and percentage values related with the variables or themes in the studies were showed in Table 9.

Table 9. Distribution of studies by variables or themes

	Variables	SSCI/ SCI		International		Conference		Thesis/ Books		Total*	
		f	%	f	%	f	%	f	%	f	%
Qualitative	Taking general opinions	-	-	3	10.4	-	-	-	-	3	10.4
	Examining the status of use	-	-	-	-	2	6.9	-	-	2	6.9
	Examining the learning environment	-	-	-	-	1	3.5	-	-	1	3.5
	Examining the effectiveness	-	-	-	-	1	3.5	-	-	1	3.5
	Examining the system	-	-	-	-	1	3.5	-	-	1	3.5
	Taking the opinions regarding use	-	-	1	3.5	-	-	-	-	1	3.5
Effectiveness	Effect on attitude	1	3.5	3	10.4	-	-	-	-	4	13.8
	Effect on learning	-	-	-	-	1	3.5	1	3.5	2	6.9
	Effect on concept	-	-	-	-	1	3.5	1	3.5	2	6.9
	Effect on perception	-	-	-	-	1	3.5	1	3.5	2	6.9
	Understanding/misconception	1	3.5	-	-	-	-	-	-	1	3.5
	Effect on outcome	-	-	-	-	1	3.5	-	-	1	3.5
	Effect on behavior	1	3.5	-	-	-	-	-	-	1	3.5
	Effect on motivation	-	-	-	-	-	-	1	3.5	1	3.5
	Effect on knowledge	-	-	-	-	-	-	1	3.5	1	3.5
Quantitative Survey	Performance determination	1	3.5	1	3.5	-	-	-	-	2	6.9
	Determination of use	1	3.5	-	-	-	-	-	-	1	3.5
	Examining technology use and its reasons	-	-	1	3.5	-	-	-	-	1	3.5
	Determining attitudes	-	-	1	3.5	-	-	-	-	1	3.5
	Total	5	17.2	10	34.5	9	31.0	5	17.2	29	100

*Since some studies had more than one variable, the total number is not equal to the number of articles.

When Table 9 was examined, it can be observed that the number of qualitative studies was very low and general opinions were taken with a frequency of %10.4. In addition, the effectiveness of tablet use on some variables were examined in many of the studies. Studies in literature had examined the effects on attitude with a frequency of %13.8, on learning with a frequency of %6.9, on concept with a frequency of %6.9 and on perception with a frequency of %6.9. In addition, it is observed that studies in journals within the scope of SSCI/SCI determined the status related with tablets and its effects on some variables were examined.

The data related with the numbers of study groups or samples in the analyzed studies showed in Table 10 while Table 11 contained data related with type.

Table 10. Frequencies of studies by number of samples

Number of Samples	SSCI/ SCI		International		Conference		Thesis/ Books		Total*	
	f	%	f	%	f	%	f	%	f	%
0-30	1	4.6	-	-	2	9.1	-	-	3	13.6
31-100	1	4.6	3	13.6	4	18.2	-	-	8	36.4
101-200	2	9.1	4	18.2	2	9.1	-	-	8	36.4
201 and more than	-	-	2	9.1	-	-	1	4.6	3	13.6
Total	4	18.2	9	40.9	8	36.4	1	4.6	22	100.0

*Since some studies did not give number of samples, the total number is not equal to the number of articles.

Table 11. Frequencies of studies by type of samples

Type of Samples	SSCI/ SCI		International		Conference		Thesis/ Books		Total*	
	f	%	f	%	f	%	f	%	f	%
Student	1	4.2	4	16.7	5	20.8	2	8.3	12	50.0
Pre-service teacher	2	8.3	3	12.5	2	8.3	-	-	7	29.2
Teacher	1	4.2	2	8.3	-	-	1	4.2	4	16.7
Department**	-	-	-	-	-	-	1	4.2	1	4.2
Total	4	16.7	9	37.5	7	29.2	4	16.7	24	100.0

*Since some studies did not give type of sample, the total number is not equal to the number of articles.
** Department includes teacher(s) and his/her classroom(s).

When the study group and samples in the studies were examined, it was observed that the frequency of studies published in SSCI journals carried out with 0-30 or 31-100 people was %4.6 whereas the frequency of studies carried out with 101-200 was %9.1. Whereas the frequency of studies carried out with 101-200 people and published in international journals was %18.2 and the frequency of studies carried out with 31-100 people was %13.6. In general, it can be observed that the frequency of working with 31-100 participants was %36.4 frequently and that the frequency of working with 101-200 participants was %36.4. In the sample types, studies in SSCI scope were carried out with pre-service teachers with a frequency of %8.3. The frequency of studies published in international journals carried out with students was %16.7, the frequency of studies carried out with pre-service teachers was %12.5. The frequency of studies carried out with teachers was %8.3 and the frequencies for students and pre-service teachers in conferences were %20.8 and %8.3 respectively. In this regard, studies were generally carried out with students with a frequency of %50.0 whereas the frequency of studies carried out with pre-service teachers was %29.2. The values related with frequencies and percentages related with data acquisition instruments can be seen in Table 12.

Table 12. Frequencies of studies by type of instruments

Type of Samples	SSCI/ SCI		International		Conference		Thesis/ Books		Total	
	f	%	f	%	f	%	f	%	f	%
Likert type scale	2	4.3	5	10.6	3	6.4	1	2.1	11	23.4
Questionnaire	2	4.3	2	4.3	3	6.4	-	-	7	14.9
Open ended question	-	-	3	6.4	2	4.3	1	2.1	6	12.8
Multiple choice test	1	2.1	1	2.1	2	4.3	2	4.3	6	12.8
Observation	1	2.1	2	4.3	1	2.1	-	-	4	8.5
Closed ended question	-	-	3	6.4	-	-	-	-	3	6.4
Interview	-	-	1	2.1	2	4.3	-	-	3	6.4
Puzzle	-	-	-	-	1	2.1	-	-	1	2.1
Video recording	-	-	-	-	-	-	1	2.1	1	2.1
Online homework	1	2.1	-	-	-	-	-	-	1	2.1
Standard exam	1	2.1	-	-	-	-	-	-	1	2.1
Rubric	1	2.1	-	-	-	-	-	-	1	2.1
Reflective note	-	-	-	-	1	2.1	-	-	1	2.1
Drawing	-	-	1	2.1	-	-	-	-	1	2.1
Total*	9	19.1	18	38.3	15	31.9	5	10.6	47	100.0

*Since more than one data collection tool was used in some studies, the total number is not equal to the number of articles.

The frequencies of instruments in the studies carried out were %23.4, %14.9, %12.8 in likert type scale, questionnaire, open ended question or multiple-choice test respectively. It was observed in the carried out studies within the scope of SSCI that the frequencies were %4.3 for likert type scale or questionnaire and %2.1 for multiple-choice test, observation, online homework, standard exam or rubric. When the international studies were examined, it was observed that the frequency of likert type scale was %10.6 and the frequency for open ended question or closed ended question data acquisition instruments was %6.4. The frequency and percentage values for applications used in tablet applications in science education showed in Table 13.

Table 13. Frequencies of studies by application

Application	f	%
Windows Journal	2	8.7
DyKnow Vision software	2	8.7
Classroom presenter	1	4.4
Classroom management system	1	4.4
Ubiquitous presenter	1	4.4
Clickers	1	4.4
InkSurvey	1	4.4
Case method teaching material manga (web browser)	1	4.4
Case method teaching material manga (e-book)	1	4.4
Power point	1	4.4
Youtube	1	4.4
GearSketch learning environment	1	4.4
The App CLAST	1	4.4
The online labs (OLabs)	1	4.4
SimPad	1	4.4
One-Note	1	4.4
Input Panel	1	4.4
Tegrity lecture capture panle	1	4.4
Sapling Learning	1	4.4
SolarWalk app	1	4.4
Educreations	1	4.4
Total*	23	100.0

*Since some studies did not give applications, the total number is not equal to the number of articles.

Standard applications for tablets had been used in some studies in literature whereas applications developed by the researchers had been used in others and relevant studies had been carried out for these. It was observed that the frequencies of Windows Journal and DyKnowVisionsoftware were both %8.7 in the studies using tablet applications. In addition, it can be observed that applications such as Classroompresenter, InkSurvey, Case method teaching material manga, TheApp CLAST are used with a frequency of %4.4.

The frequency and percentage values related with the concepts of science examined during tablet studies in science education showed in Table 14. Whereas the images in studies related with science concepts were indicated in Figures 1 and 2.

Table 14. Frequencies of studies by science concept

Science Concept	f	%
Electricity	3	17.1
Chemistry concept / course	2	11.8
Biological course/ lab	2	11.8
Physical concept/ course	2	11.8
Magnetism	1	5.9
Atomic physics	1	5.9
Gear and chain systems	1	5.9
Climate	1	5.9
Science laboratory	1	5.9
Science course	1	5.9
Solar environment	1	5.9
Kinetic theory of gases	1	5.9
Total*	17	100.0

*Since some studies did not give science concepts, the total number is not equal to the number of articles.

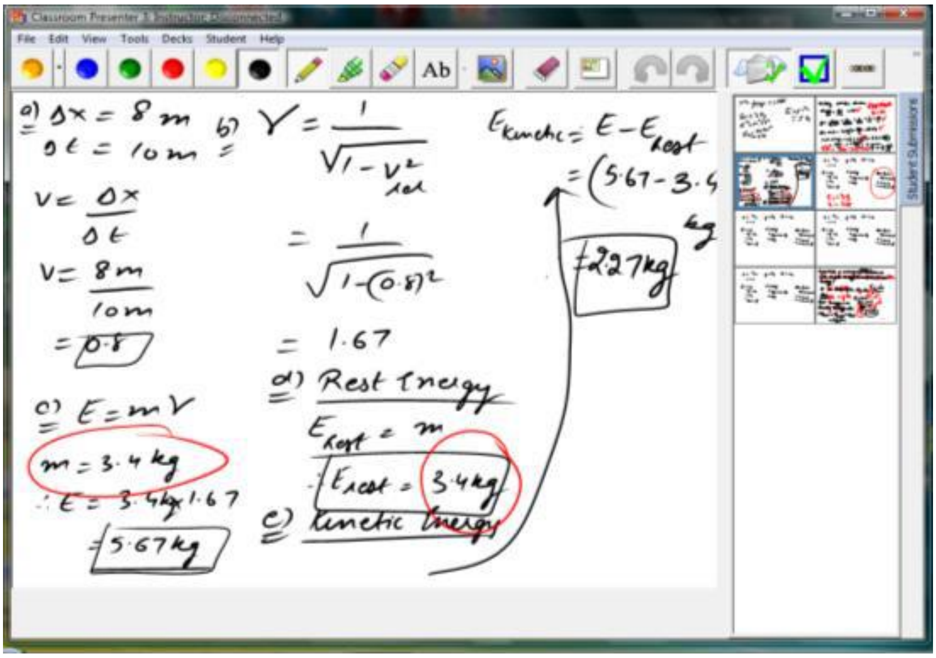

Figure 1. A screen shot from the teaching process of electricity and magnetism (Antimirova & Milner-Bolotin, 2010)

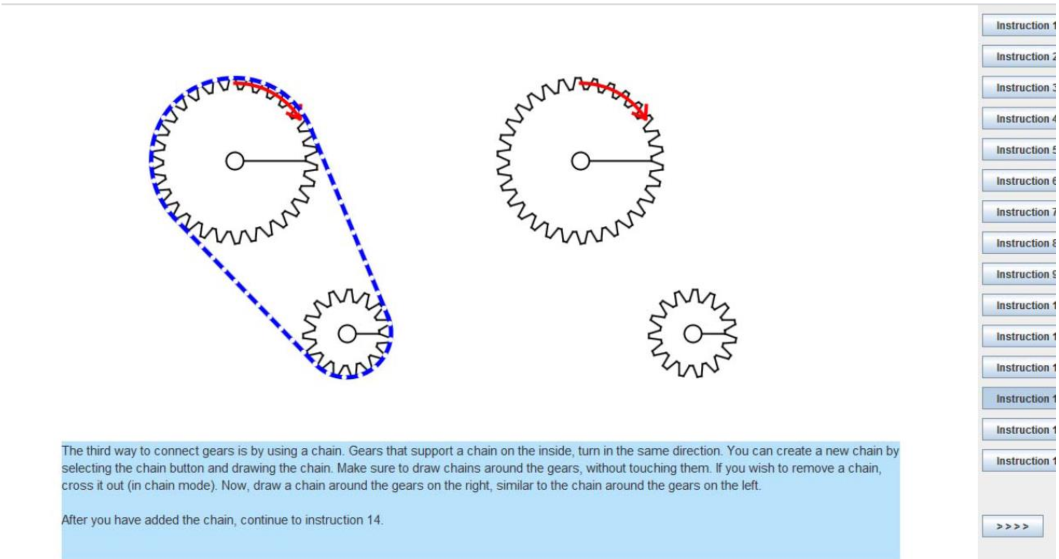

Figure 2. A screenshot from the teaching process of Gear and chain systems topic (Leenaars, vanJoolingen, Gijlers & Bollen, 2012)

As seen in Table 14, it can be observed that the tablets had been used in science education with a frequency of %17.1 for the electricity topic, %11.8 during chemistry concepts/course, %11.8 during biology lesson/laboratory and %11.8 during physics classes. In addition, it can be observed that studies had been carried out on topics such as magnetism, atomic physics, gear and chain systems. Of these, the screen shots related with the teaching processes of electricity and gear and chain system were given in Figures 1 and 2. However, in some of the studies indicated that done in science labs or science class, it did not focus on a science subject. In addition, some of the qualitative (such as taking general opinions) and survey (determining attitudes) studies could not focus on a certain science concept and thus they could not be examined regarding to this variable.

4. *What are the results of the studies regarding of tablets in science education?*

The frequency and percentage values related with the results acquired from studies carried out on tablet use in science education was presented in Table 15.

Table 15. Frequencies of studies by results

	Results				
Theme	Code	f	%	f	%
Effect on cognitive properties	Helps learning	3	12.0	12	48.0
	As an effective learning tool	2	8.0		
	Increases student performance	2	8.0		
	Increases products of learning	2	8.0		
	Increases learning opportunities	1	4.0		
	Having a positive impact on participants	1	4.0		
	Increasing learning effectiveness	1	4.0		
Effects on use	Provides positive attitude towards the use of technology	1	4.0	7	28.0
	Increases the attitudes of parents of students who use tablets during lessons	1	4.0		
	Positively increases the attitudes towards tablet use	1	4.0		
	Use of tablets as note taking devices	1	4.0		
	Teachers supporting the use of tablets in class	1	4.0		
	That e-books are an innovation	1	4.0		
	Establishing a framework for the evaluation of applications in science education	1	4.0		
Effects on affective properties	Making lessons more fun	2	8.0	6	24.0
	Increasing the motivation/interest of students	2	8.0		
	Ensuring the visualization of complex materials	1	4.0		
	Enjoyed by students	1	4.0		
Total		25	100.0	25	100.0

Table 15 was included data related with the results obtained from the studies on tablet use in science education. It was observed that the acquired data were classified under the subjects of effects on cognitive properties, use and affective properties. It was concluded that the studies help learning with a frequency of %12.0, that they were effective learning tools with a frequency of %8.0, that they increase the student performance with a frequency of %8.0 and increase the learning outcome with a frequency of %8.0. In addition, it was also concluded that it makes lessons more fun due to its effects on affective properties with a frequency of %8.0 and that it increases the motivation/interest of students with a frequency of %8.0.

5. *What are the suggestions for researchers, teachers, curriculum developers and policy makers regarding the use of tablets in science education?*

The data related with the suggestions included in studies carried out regarding tablet use in science education was showed in Table 16.

Table 16. Frequencies of studies by suggestions

Suggestions		
Code	f	%
Preparation of software that leads and contains ready to use activities	1	11.1
Developing teaching methods that will enable sharing via tablets	1	11.1
Carrying out studies in which traditional methods are compared with tablet based teaching methods	1	11.1
Carrying out more studies on higher level and education output	1	11.1
Carrying out studies to examine how tablets can be used more effectively	1	11.1
Increasing the number of studies that acquire data via various other methods	1	11.1
Modifying the applications used	1	11.1
Carrying out studies which examine the effects of applications developed	1	11.1
Carrying out studies with a greater number of participants	1	11.1
Total*	9	100.0

*Since some studies did not give suggestions, the total number is not equal to the number of articles.

As can be seen from Table 16, it had been stated with a frequency of %11.1 that software that leads and contains ready to use activities should be developed, it had been stated with a frequency of %11.1 that studies should be carried out in which traditional methods are compared with tablet based teaching methods and it had been stated with a frequency of %11.1 that studies should be carried out that examine how tablets can be used more effectively.

Discussion and Conclusions

According to the results obtained from the study, it is observed that 25 studies carried out related with tablet use in science education. Only four of these studies published in Computers & Education, Advances in Physiology Education and Journal of Chemical Education which were included in the SSCI/SCI scope. It was understood that the other studies generally published in international journals or presented at conferences. When journals and conferences were examined, it was observed that they were related with presenting and discussing new educational environments, best practices and case studies on innovative technology-based learning strategies, presenting activities, laboratory experiments, instructional methods and pedagogies. In addition, it was stated in journals and conferences that the objective was to develop the understanding of learning and teaching starting from pre-school to higher education and to contribute to the betterment of education. In this regard, it can be stated that the studies published in relevant journals or conferences. However, when the journals in which the studies published are examined, it is understood that in general they were the journals that focus more on education or science education. On the contrary, very few studies observed in technology focused journals related with tablet use in science education. In this regard, it was thought that more studies should be carried out related with tablet use in science education which aim to be published in technology focused and science education related publications. In addition, when the studies were examined it was observed that only four of the studies published in SSCI/SCI scope international journals. In this regard, it was understood that the number of studies on tablet use in science education was low in important journals surveyed via international databases. However, it was thought that this was more related with difficulties of publishment in SSCI/SCI scope international journals rather than being related with the topic itself. Olkun (2006) stated in a study that the two most important obstacles facing those who wish to publish in international scientific journals were their language proficiencies – their lack of being able to write in a scientific style and the fact that their research topics selected from among outdated or insignificant topics. When it was considered that tablet use in science education was a novel topic, it was thought that important publications can be carried out which can be published in important journals cited in indexes.

Studies related with tablet use in science education started to be carried out in 2007 that the number of studies increased to reach four in 2012 whereas nine studies were carried out in 2013. In this regard, it can be stated that parallel to the rapid advancements in technology, the number of studies had increased related with tablet use in science education. When we looked at 2014, it can be observed that there were six studies. This was thought that journals had not completed all their issues in 2014 and that conferences had not been carried out. In addition, it was observed as a result of the analyses made that 25 articles had been found. When a quantitative evaluation was made, it can be stated that the number of studies on tablet use in science education was very low. However, it was thought as a result of the studies carried out that the number of studies in this field had increased rapidly in 2013 and that they have continued to increase over time accordingly. In addition, even though studies on tablet use in science education examined, it was thought that some studies had not been reached. Because it was observed that in some studies the names of special applications used in tablets are used instead of the term tablet. In their study Looi, Chen and Ng (2010) used Group Scribbles in the science classroom and examined the learning effectiveness collaborative activities. They used Tablet PCs, but this word was not used title or keywords. Despite the use of tablets in some studies in the literature, the titles include general terms such as mobile devices or mobile learning environment. Liu, Lin and Paas (2014) examined the effects of prior knowledge on learning in a mobile learning environment about plant leaf morphology for primary school. Furió, González-Gancedo, Juan, Seguí and Costa (2013) presented an educational game for an iPhone and a Tablet PC about the water cycle. In this regard, there can be said that these and similar studies were related to the use of tablets in science education. In the review of study which the use of tablets in science education, we could not be reached to some studies. Because when it was looked at topics or keywords in the study, tablet or other mobile devices were being used which was not understood. When both the large number of applications used with tablets and the presence of many tools in mobile devices were considered, it was not possible to scan all applications and this was among the limitations of the study. In addition, it was known that the daily use of tablets and in parallel the use of tablets in educational environments started quite recently. Similarly, Ozkale and Koc (2014) asserted in their studies that there was a significant increase in the popularization of tablet computers starting with 2010 and beyond, but the number of studies examining the results of tablet computer use for educational purposes was almost rare. Accordingly, it was normal that the number of studies related with tablet use in science education was low.

As a result of the analyses carried out, it was observed that the authors made publications generally as one, two or three authors. Bacanak, Degirmenci, Karamustafaoglu and Karamustafaoglu (2011) carried out a study in which they examined the articles on science education regarding the number of authors in which they concluded that 2/3 of the studies have one or two authors. In this regard, it can be concluded that the studies were generally carried out with a smaller number of authors. It was observed as a result of the analysis carried out that the highest number of studies on tablet use in science education were carried out in Turkey and United States followed respectively by Canada, United Kingdom and Japan. It can be stated that this was because of technology supported applications started to be incorporated in the education policies of the countries which in parallel had led to the increased use of tablet use in classrooms. Many projects was carried out in recent years in the world and in Turkey which were related with the integration of technology to education and many projects was applied in the USA to spread the use of technology at the national and state level (Pamuk, Cakir, Ergun, Yilmaz and Ayas, 2013). Reynolds (2011) carried out a study in US in which he stated that in parallel with the popularity of tablets and smart phones, they carried out a study putting forth that they reach %20 of the university students until the end of 2012. Whereas in Turkey, the FATIH Project anticipates the provision of laptops, LCD panel, interactive board and internet infrastructure to ensure that information technologies appeal to a greater number of senses in the learning-teaching process in order to enhance technology used at schools and to ensure the equality of opportunity in education (FATIH 2013). In this regard, it was observed that schools and educational environments have been carried out projects related with the use of technology and tablets. It can be stated in parallel that the number of studies was greater on tablet use in these countries. However, it can also be stated that the number of studies was limited and that there was a need for more studies.

The rationales for studies on tablet use in science education specified as, the fact that the number of tablet related studies was low (Balci, Kenar and Usak, 2013), insufficiency of tablet related materials for teachers (Egusa et al., 2014), popularization of tablet use in education (Daikoku, Funaoi, Kusunoki, Takenaka and Inagaki, 2013) and the increase of student learning as a result of tablet use (Director and Hrepic, 2007). It can be seen in the stated rationales that in general the insufficiency in the field was emphasized. Ozkale and Koc (2014) underlined that scientific studies that examine the use of tablets in educational environments in Turkey as well as their educational potential had increased with the FATIH project but also added that the number of studies was still limited. In this regard, it was quite normal to state the insufficient number of studies on tablet use in science education as a rationale for conducting studies in this field. Whereas six of the rationales put forth in the studies were related with science, rationales regarding tablet use in education had been put forth without establishing a relation with science in 10 studies. When it was considered that all the studies carried out are related with tablet use in science education, the rationales should be related not only with tablet use in education but also with the nature of science as well. In addition, some studies did not include these at all which can be specified as a shortcoming of these studies with regard to their value. In this regard, it was thought that when writing down the studies related with tablet use in science education, stating the rationales and relating tablet use with science will increase the quality of the studies carried out.

It was determined as a result of the studies carried out that the objectives of the studies carried out on tablet use in science education were examination of the effects of tablets on the student (Morris, Ramsay and Chauhan, 2012), on student performance (Pryor and Bauer, 2008) and the examination of the effectiveness of tablet material (Daikoku et al., 2013). In addition, there were also studies in the relevant literature in which opinions of teachers related with tablets were taken (Dasdemir, Cengiz, Uzoglu and Bozdogan, 2013), which aim to develop tablet applications (Erhart, 2013) and which examine the attitudes of students regarding technology in tablet applications (Kenar, Balci and Gokalp, 2013). When the objectives of the studies were examined, it can be observed that studies generally carried out to examine the effects of tablets on student performance, success, attitude, learning gains or outputs. In this regard, it can be stated that the studies focused only on cognitive properties and attitude. Even though there were many variables which studies by can be establishing a relation between science and technology (tablets, smartboards etc.), no studies were determined which examine the effects of tablet use on different variables such as entrepreneurship, knowledge and communication skills. In addition, it can be stated as a result of the analyses carried out that there were studies which aim to develop tablet applications. It was considered that these studies were important for the field and that the tablet applications which will be developed by establishing a relation between science education and tablets will be important for school managers, teachers, teacher candidates and students. It can be stated that such studies will be important for the field.

It was observed that experimental/empirical method (Nedungadi, Raman and McGregor, 2013; Pryor and Bauer, 2008; Schneps, Ruel, Sonnert, Dussault, Griffin and Sadler, 2014), descriptive survey (Dasdemir et al., 2013), case study (Egusa et al., 2014; Price and De Leonce, 2008) and survey method (Kucukaydin, Bozdogan and

Ozturk, 2014) was used in studies on tablet use in science education. In addition, it was also understood that experimental/empirical method, mixed method and controlled study was used in SSCI/SCI scope journals, whereas experimental method, descriptive survey, survey method was used in international journals. It can be expressed as a result of the analyses that the number of qualitative studies was very low and these are the studies in which general opinions required regarding tablets. In addition, it was observed in many studies that the effectiveness of tablet use examined on different variables such as attitude, learning, concept and perception. In this regard, it was thought that long-term qualitative studies should also be carried out in addition to studies using experimental design which examine the effectiveness with regard to certain variables.

When the study group and sample groups in studies on tablet use in science education were examined, it was observed that 0-30, 31-100 and 101-200 people had been used in SSCI scope journals. Whereas the number of participants for articles published in international journals varies between 101-200, 31-100 or 201 and above. In this regard, it was normal to work with a greater number of participants if it is considered that the studies were more quantitative. When the sample group types was examined, it was observed that teacher candidates was preferred in studies published in SSCI scope journals, whereas students and teacher candidates was preferred for studies published in international journals and students were used for conferences. In general, it can be said that studies carried out with students and teacher candidates. This was since the studies to examine the effects of tablet applications in science education on the students or the examination of student related issues. In addition, it can be stated that there is need for a greater number of studies with a wider scope which will be carried out with students and teachers.

It was observed as a result of the analyses carried out that the data acquisition tools used in the studies were likert type scale (Olsson, 2013), questionnaire (Green, Hechter, Tysinger and Chassereau, 2014; Revell, 2013; Slough, Erdogan, Cavlazoglu, Wakefield and Akgun, 2012), open ended question (Kucukaydin et al., 2014) and multiple choice test (Pryor and Bauer, 2008). Likert type scale, questionnaire, observation, multiple-choice test, rubric, online homework or standard exam was used in studies carried out within the scope of SSCI. Whereas it was observed that likert type scale, open ended question or closed ended question was used as data acquisition tools in international studies. As stated by Simsek et al. (2009), it can be stated that the reason for the preference of surveys, tests and scales was the fact that survey studies carried out more within the scope of quantitative paradigms. In this regard, likert type scale, multiple choice test and questionnaire was used even though the studies were mainly quantitative. On the other hand, it was understood that the number of studies was quite low in which various methods such as observation and interview were used which were mainly used in qualitative studies.

It was determined as a result of the analyses carried out that in some of the studies examined standard tablet applications that come with the tablets was used, whereas in others tablet applications developed by the researchers was preferred and studies was carried out accordingly. Windows Journal (Antimirova and Milner-Bolotin, 2010; van Oostveen, Muirhead and Goodman, 2011) and Dy Know Visionsoftware (Director and Hrepic, 2007; Hrepic and Miller, 2009) applications was preferred in tablet applications used studies. In addition, it was also observed that applications were used such as Classroompresenter, InkSurvey, Case method teaching material manga, TheApp CLAST (Macario, Cattadori, Bianchi, Zattin and Talarico, 2013), Educreations (Lehtinen and Viiri, 2014).. In this regard, it can be stated that it would be suitable to developed applications which can be used in science education or to carry out studies by establishing the relationships between existing applications and science. It was determined as a result of the study carried out that tablets used most extensively for the electricity subject as well as in chemistry concepts/course, physics concepts/course, physics lessons and biology lessons/laboratory. In addition, it was also observed that there are studies on the use of tablets in laboratory classes as well. This was thought that simulations and animations were used more extensively for such topics or during laboratory courses. In addition, when the analyzed studies were examined, it was observed that research studies carried out in physics, chemistry and biology lessons but that these were not subject based studies. In this regard, when it was considered that there were tablet applications suited for each topic; it was very likely for studies to be carried out on all topics.

When the main results acquired from the study on tablet use in science education were examined, it was concluded that tablets help learning with regard to cognitive features (Kucukaydin et al., 2014), that it was an effective learning tool (Egusa et al., 2014), that it increases student performance (Leenaars et al., 2012) and that it increases learning outputs (Hrepic and Miller, 2009). As can be understood, the use of tablets in science education made positive contributions to the learning of students. In addition, it was also concluded that tablets make the lessons more fun due to their effects on cognitive properties (Uzoglu and Bozdogan, 2012) thus increasing the motivation/interest of students (Dasdemir et al., 2013). It can be put forth that the interest of technology age individuals increase with tablet use and that a more entertaining classroom environment was attained. It was suggested as a result of the analyses made with regard to tablet use that guiding software's should be developed which contain ready activities (Ozdemir and Bozdogan, 2014), that studies should be carried out which compare traditional methods of teaching with tablet based teaching (Erhart, 2013) and that methods for increasing the effectiveness of tablets should be examined (Leenaars et al., 2012).

Recommendations

When studies on the use of tablets in science education were examined, it was observed that the use of computers, smartboards and tablet applications increase along with technological advancements and that studies related with these topics were being carried out. However, it can be stated that the number of such studies was limited and that there were many gaps in the field which should be filled with further studies. It was understood that the studies carried out with regard to tablet use in science education were mostly experimental and that they focus more on cognitive properties and the attitude towards technology. On the contrary, there was a need for studies that examine the effects of tablets on the creativity, entrepreneurship, knowledge and communication skills of students by establishing the relation between science education and tablets. In addition, studies should be carried out which use many data acquisition tools together such as interview, observation and surveys to relate the data acquired as such in order to be able to publish the studies in SSCI scope journals. It can thus be stated that such studies were required for tablet use as well.

It can be stated that there were studies which aim to develop tablet applications among the examined studies. It was thought that these studies were important for teachers, students as well as the researchers in the field. Because the applications that will be developed can be tested by the researchers and applied by the teachers and students thus ensuring the use of different materials during the lessons. In this regard, it was thought that tablet applications that will be developed by relating them with science will be important for the relevant literature and that they will fill wide gaps in the field. It can be suggested to develop tablet applications by establishing relations between science and tablet use and to carry out studies which test these applications.

It was observed that tablet applications were made and their effectiveness was examined in the studies. However, no study was found which examine the effects of tablet use with regard to safety and health. In this regard, it was thought that studies should be carried out which examine the effects of tablet use in classrooms on the health and safety of individuals. In addition, it was thought that it will be important to carry out studies focusing on the provision of individual and tablet interaction.

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Investigating Preservice Science Teacher Ethical Sensitivity through Computer Game and Video

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Abstract

A computer-based simulation, Hazelton High at REST (HHR), with embedded performance-based assessments and Likert-type survey questions was created to assess preservice teacher recognition of racial and gender intolerant behaviors. The simulation was modeled after the Racial Ethical Sensitivity Test (REST), a reliable video-based assessment, measuring professionals' ethical sensitivity for cultural competence and recognition of intolerant behaviors in school settings. Ethical sensitivity skills, based on education professional ethics, are used to determine knowledge of ethical responsibility and professional attitudes and behaviors. A mixed-methods comparison study was conducted between HHR and the REST-video with 31 preservice science education students to investigate the effect of each on their ethical sensitivity. A post-simulation assessment was also conducted to determine and the usability and perception of HHR. It was hypothesized; HHR, an immersive simulation, would affect perspective taking of preservice science teachers and indirectly influence their ethical sensitivity. Data analysis determined ethical sensitivity score (EES) for HHR and REST-video using a survey and performance-based assessments. Post-simulation interview helped inform how a participant perceived the HHR. Results indicate the REST-video group had a significantly higher EES than the HHR group. Performance-based assessments within HHR showed a more comprehensive and complex picture of participant EES. The implication of this work for science education programs to use professional codes as a guide for evaluation and development of candidate disposition concerning cultural competency and the use of Serious Educational Games (SEGs) as ethical sensitivity assessments.

Introduction

Science education standards set expectations and principles for teachers to uphold the highest ethical standards and recommend teachers gain professional dispositions to support learning (Council for the Accreditation of Education Preparation (CAEP) 2013; National Science Teacher Association Standards (NSTA), 2012). Furthermore, the NSTA Standards for Science Teacher Preparation (NSTA-SSTP) (NSTA, 2012) was written to ensure science teacher education programs prepare preservice teachers with the appropriate knowledge and skills that are necessary to create learning environments that engage diverse learners. The Principles of Professionalism for Science Educators (PPSE) calls for science educators to conduct themselves in a moral and ethical manner in order to provide all learners with the best science education (NTSA, 2010). Essentially, the language in these documents speaks to the moral foundations and basis of teaching science with ethical sensitivity and competency in cultural and linguistic diversity. Despite the principles espoused in these standards, there is a continued need to connect science teacher education standards with professional ethics and cultural competence.

Too often, the professionalization of teaching places emphasis on knowledge and skill development and less attention is given to ethical and moral development. Fenstermacher (1990) reminds us why teaching is a moral activity:

> What makes teaching a moral endeavor is that it is, quite centrally, human action undertaken in regard to other human begins. Thus, matters of what is fair, right, just, and virtuous are present. Whenever a teacher asks a student to share something with another student, decides between combatants in a schoolyard dispute, sets procedures for who will go first, second third, and so on, or discusses the welfare of a student with another teacher, moral considerations are present. The teacher's conduct at all times and in all ways, is a moral matter. For that reason alone, teaching is a profoundly moral activity (p. 133).

Highlighting the essence of situating science education in a sociocultural perspective, Lemke (2001) argued, “The most sophisticated view of knowledge available to us today says that it is a falsification of the nature of science to teach concepts outside of their [students’] social, economic, historical, and technological contexts” (p. 300). Overall, science educators facilitate the development and construction of science concepts for learners by assuming the responsibility for enabling each learner to reach their potential. This includes empowering learners to think and respond with their cultural, ethnic, and linguistic differences, making science personal rather than abstract (NSTA, 2006). The Preservice Science Standards, Standard 6: Professional Knowledge and Skills speaks more specifically, “Effective teachers of science strive continuously to improve their knowledge and understanding of the ever changing knowledge base of both content, and science pedagogy, including approaches for addressing inequities and inclusion for all students in science” (NSTA, 2012).

Teachers in schools populated by underrepresented learners (e.g., racial/ethnic minorities, economically disadvantaged, immigrants) are guided by their personal beliefs, attitudes, and knowledge bases and can easily be unaware of their actions in the classroom (Fras-Abder, 2001; Welton & Martinez, 2014). Teaching is a “socially negotiated activity” that requires the refinement of moral sensibilities (Buzzelli & Johnston, 2002). If unfamiliarity and fear of teaching underrepresented learners are coupled with gaps in knowledge and skills, teachers’ actions may be perceived as not enriching the curriculum with diverse cultural perspectives (Carter, Larke, Singleton-Taylor, & Santos, 2003; Villegas & Lucas, 2002), not recognizing acts of intolerant behavior, and being unaware of cultural influences on learning (Bryan & Atwater, 2002). Thus, it is appropriate to develop preservice teacher’s ethical sensitivity skills to create equitable teaching and learning environments in science classrooms. Teacher preparation programs have a critical responsibility in this endeavor. The rationale for Standard 3: Candidate Quality, Recruitment, and Selectivity notes that educator preparation provider’s responsibility begins with purposeful recruitment, continues through selectivity, and monitoring progress while providing support for proficient completion and being chosen for employment opportunities.

The Science Classroom

Science teachers as much as any other teacher will be confronted with dilemmas surrounding learner identity and unconscious biases. Learners often seek out teachers for advice concerning the social issues in their lives and these issues can arise during classroom discourse. Science teachers are not merely employed or expected to just teach science. The PPSE instructs science teachers to “reflect a positive professional image by being cognizant of the image portrayed to students, parents and the community through speech, attire, and action…uphold the highest standards of ethical behavior and be positive role models…protect, respect, and empower students” (NSTA, 2007, p. 1-3). This language calls for the attention to the development of professional ethics and professional responsibility in science teachers during their tenure in science education programs. CAEP acknowledges research that supports non-academic teacher qualities often called attributes, dispositions and abilities. Further, CAEP recognizes Interstate Teacher Assessment and Support Consortium (InTASC) standards as an area of growing development, research and interest in teacher knowledge, disposition and performance. The Professional Knowledge and Skills NSTA Preservice Science Standard, combines continuous improvement of content knowledge and science pedagogy with “approaches for addressing inequities and inclusion for all students in science.” (2012).

Performance-based Assessments and Computer Games to Assess Professional Performance

Researchers and scholars in various professions have suggested that performance-based assessments and simulations provide insight to alternative pathways of thinking for professionals. For example, Hmelo et al. (2001) used case-based scenarios containing detailed patient histories to assist pre-medical professionals in learning to design clinical trials for oncology treatment. Performing medical consultations is an area where there was extensive use of cased-based simulations. Waldmann, Gulich and Zeitler (2008) utilized the case-based simulations and had medical students role-play as a physician. The researchers noted that simulations provide information beyond a paper-based assessment, mentors had a better idea about how participants approached a problem, and simulations reduced the number of training days (Hmelo et al., 2001; Waldmann et al., (2008).

Additionally, attributes for using digital technologies to study human behavior are, increased realism (Frenz, 2007), incorporating a sense of presence (Annetta & Holmes, 2006; Tung & Deng, 2006), presenting case-base scenarios (Annetta et al., 2009; Waldmann et al., 2008), and use of a risk-free, immersive setting that supports constructivist learning by causing cognitive dissonance (Dede, 2005; James Gee, 2003; Shaffer, 2007). Shaffer suggested that simulations are effective for training because a person put into a simulated world learns to be, think, and do within the parameters of the rules implied in the simulation. This is especially evident for role-playing simulations. Participants involved in role-playing, immersive and case-based scenarios are actively involved with enhanced realism and perspective taking. Perspective taking provides the opportunity to induce cognitive conflict and consider others' viewpoints, an element of ethical sensitivity and moral development. This allows other abilities, skills, and knowledge to be assessed and since assessment drives learning, performance-based assessments can benefit teaching and research alike (Frenz, 2007; Waldmann et al., 2008). Ethical sensitivity skills make unconscious biases conscious, allow a professional to see the situation from the standpoint of the other and connects the professional regulations, codes, and norms and when they apply.

In respect the extant literature, the study discussed in this paper was a response to a call to action from the science education research community (Brown, 2006; Bryan & Atwater, 2002; Fraser-Abder, 2001) and science education professional organizations (AAAS, 1989; NSTA, 2007, 2012) for innovative methodologies that encourages ethical responsibility and creates learner-centric, culturally responsive learning environments in science classrooms.

Theoretical Perspective

This investigation was situated in the theoretical framework of the Four Component Model (FCM) (see Figure 1), which is grounded in ethical development and professional ethics. Rest (1986) used his investigations in moral development and generated the FCM for morality as an explanation for the effects of cognition, affect, and social dynamics on moral action. With the implementation of the Defining Issues Test (DIT) and the FCM, Rest changed how moral development was viewed and assessed (Rest, Narvaez, Bebeau & Thoma, 1999). This change moved traditional thinking about moral development from stage development theory to schema theory. According to Rest, cognition and affect interact in all areas of moral behavior (Bebeau & Monson, 2008). The FCM identifies the following four integrated abilities as needed conditions for effective ethical decision-making and behavior (a) moral sensitivity, recognize the situation as moral, empathize with the effect on others; (b) moral judgment, integrating and weighing various moral considerations; (c) moral motivation, prioritize moral values relative to other values; and (d) moral implementation, requiring moral character, conviction and courage (Brabeck et al., 2000; Rest & Narvaez, 1994). Following Rest, Bebeau (Bebeau, Rest, & Yamoor, 1985) developed the Dental Ethical Sensitivity Test (DEST) for dental students and Brabeck (Brabeck et al., 2000) developed the Racial Ethical Sensitivity Test (REST) for preservice teachers. Both instruments assess the first component of the FCM, moral sensitivity; in their respective professional areas (see Figure 1). A stimulation called *Hazelton High at REST* was developed for this study using the FCM framework; the content for the game is from the REST for preservice teachers.

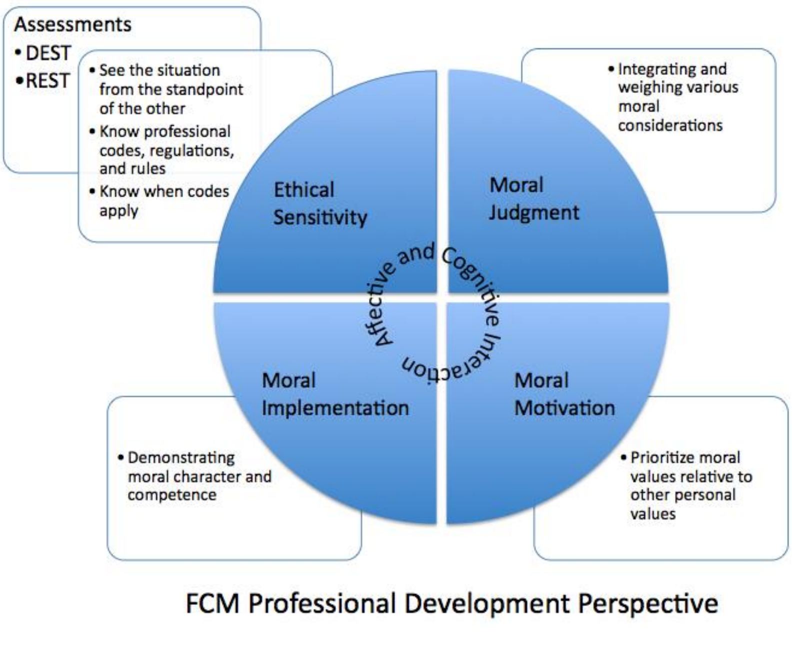

Figure 1. FCM professional development perspective

Research Purpose

In order for implementation of ethical sensitivity skills to occur, the professional must recognize the moral aspects in the situation (Bebeau & Monson, 2008). Therefore, the focus and rationale for this study was to facilitate recognition of racial and gender intolerant behaviors, moving unconscious bias to awareness as a way to initiate judgment, motivation and implementation of professional responsibilities; in other words to effect preservice science teachers' ethical sensitivity. This intent was achieved by creating a first-person perspective Serious Educational Games (SEG) (Annetta, 2008) *Hazelton High at REST*, which contains performance-based assessments and emulated after the REST for preservice teachers. The REST assesses educator ethical sensitivity to racial and gender intolerant issues in schools (Brabeck et al., 2000; Sirin, Rogers-Sirin, & Collins, 2010; Sirin, Brabeck, Satiani, & Rogers-Sirin, 2003). The rationale to use a SEG to assess ethical sensitivity focused on the immersive nature, enhanced realism, and the ability to cause cognitive dissonance in a risk free environment when using simulations (Bos, Shami, & Naab, 2006; Eck, 2006; Gee, 2005; Hmelo et al., 2001; Macedonia, 2002; Shaffer, Squire, Halverson, & Gee, 2005). The implementation of a computer simulation in the evaluation and development of professionalism in science teacher education might encourage more reflection of educator responsibility, awareness to implement professional standards, provide opportunities for technological instruction, and present a format to explore and increase ethically defensible responses to intolerant behaviors.

Hazelton High at REST

The current methodology involved the creation of the SEG *Hazelton High at REST* (created by the first author) with specific immersive characteristics and the implementation of an embedded performance-based assessment. The creation of *Hazelton High at REST* is a technological study and is out of the scope for this article. The embedded content in the SEG was grounded in professional ethics and ethical development and based on recommendations of NSTA professional standards and science education research. *Hazelton High at REST* was a response to issues associated with gaps in science teachers' ethical sensitivity and multicultural competence. Using a SEG with performance-based assessments of professional attitudes and behaviors were used as evidence for knowledge of ethical responsibility.

Hazelton High at REST was compared with the video REST to elucidate usability issues of the SEG as well as its use as a performance-based assessment for ethical sensitivity with science educators. The preliminary research question for this study was: how does an immersive 3D SEG affect ethical sensitivity of science educators when compared to the video case assessment? In addition to the embedded assessment, three open-ended questions were asked immediately following the SEG experience to gain more information concerning how the participants perceived the SEG. This research is part of a larger quasi-experimental comparison study between preservice and in-service science teachers in addition to comparing the SEG and video experiences.

Assessments of Professional Ethics

The DEST assesses a dental student's ability to identify and respond to moral dilemmas embedded in dentist-patient interactions via an audiotape. Bebeau rephrased moral sensitivity to ethical sensitivity because the ability of professionals or training professionals to interpret factors directly related to obligations in their professional code of ethics was being assessed.

Similar to the DEST, the REST assesses an educator's ability to recognize racial and gender ethical violations embedded in interactions between education professionals and learners using video recordings instead of audio recordings. Brabeck et al. (2000) depicted overt and covert behaviors in the REST videos, that violated ethical principles of professional codes of ethics from the teaching, social work, school administration, and school psychology professions, as well as groups who worked specifically with learners from culturally and linguistically diverse populations. Six ethical principles common to all professional codes reviewed were incorporated in the REST. They were; 1) professional competence, 2) integrity, 3) professional and scientific responsibility, 4) respect for others' rights and dignity, 5) concern for others' welfare, and 6) social responsibility. Focusing on ethical sensitivity skills for racial and gender intolerant behaviors in schools, Brabeck et al., (2000) specified the need for educators to (a) recognize verbal and nonverbal behavior; (b) identify the needs or wants of others in the situation; (c) predict others reactions to help; and (d) to respond with appropriate concern.

The DEST and REST assessments are similar in that both ask the training professional to assume the role of the professional in the scenarios thereby initiating a role-playing assessment. The scenarios present clues about ethical issues without signaling what the issue is or what professional responsibility is needed (Bebeau & Monson, 2008). Both assessments ask open-ended interview questions to determine ethical sensitivity on a scale of 1 to 3, thus providing researchable variables and authentic measures of professional performance (Bebeau & Monson, 2008).

Hawthorne Effect

The Hawthorne Effect as defined by Payne and Payne (2004) became an additional lens for this study. Initial participant reaction and responses to *Hazelton High at REST* led to a re-examination of the post-SEG responses and opened consideration of the Hawthorne Effect. According to Payne and Payne, "The Hawthorne Effect is the tendency, particularly in social experiments, for people to modify their behavior because they know they are being studied, and so to distort (usually unwittingly) the research findings," (p. 107). The following question was investigated during a re-examination of responses after participants completed *Hazelton High at REST*; did the immersive 3D SEG interfere with participant recognition of being studied?

The Hawthorne studies contributed to a deeper appreciation of factors affecting participants and encouraged social science and education researchers to focus more on the interactions between the participant and the study environment (Holden, 2000; Peacock, 2005). Investigations in this realm ask about the effectiveness of interventions used with professionals and the transfer of skills to work environments. Separating which parts of an intervention improved the performance of a professional is desirable yet complex and the Hawthorne Effect shed light on the "artificial nature" of these types of studies.

Methods

Hazelton High at REST was an immersive first person SEG comprised of two interactive REST scenarios (explanation in the next section) utilizing original audio tracks, five interspersed performance-based prompts, 36 Likert-type survey questions, and three post-SEG prompts, all of which unfold at a fictitious virtual high school that provided context for the REST SEG scenarios. An NSF grant provided funding to create the high school SEG containing two REST scenarios, Basketball Practice (BP) (see Figure 2) and Faculty Lounge (FL) (see Figure 3).

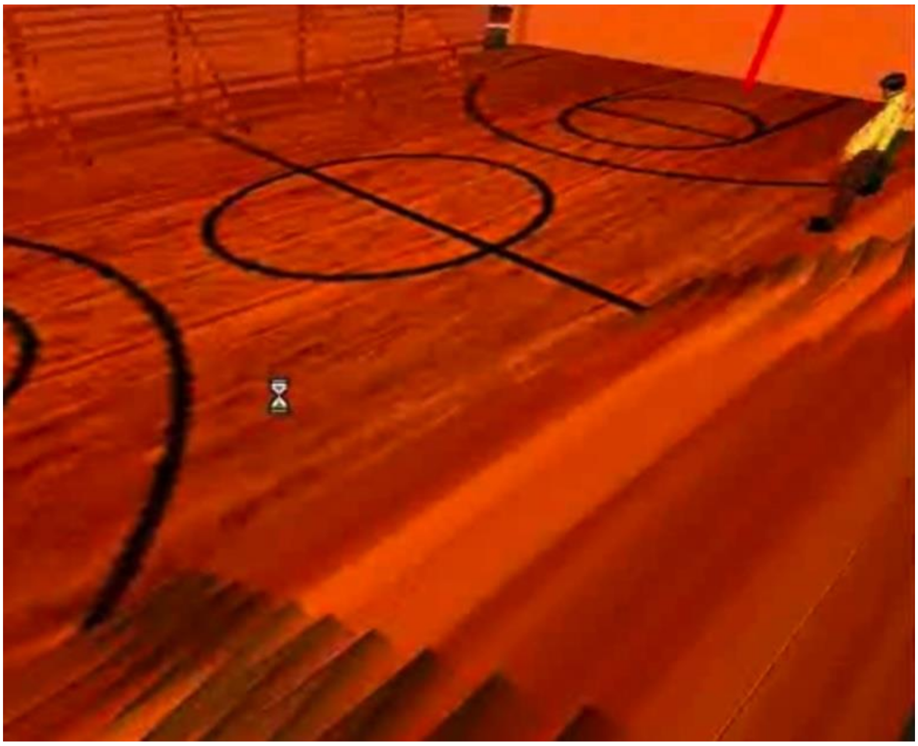

Figure 2. Screen shot of basketball practice scenario

Figure 3. Screen shot of student in the school counselor's office

A drag-and-drop authoring software was used to transform the original video format into an interactive first person SEG. *Hazelton High at REST* contained virtual characters, an audio track, and school settings similar to the REST video scenarios to facilitate a comparison study and gain knowledge about the usability of the SEG. The BP and FL scenarios occurred in a gymnasium, student counselor's office, and faculty lounge of a high school. Hazelton High SEG contained these virtual environments as well as a science classroom, laboratory prep room with desks and office space for five teachers, hallways, and a locker room. The additional rooms were designed to influence immersion during the SEG experience. Participant responses about the effect of the SEG on their responses initiated an additional exploration in the Hawthorne Effect (Adair, 1984; Holden, 2000; Payne & Payne, 2004).

Video REST instrument

The REST was constructed around identifying intolerant racial and gender related behaviors that signify ethnically insensitive conduct in US schools. The instrument comprised of five video scenarios. Embedded in each scenario were behaviors depicting five to nine ethical issues; eight were in the BP and nine in the FL. The quantitative version of the REST and Quick-REST (Sirin et al., 2010), uses both BP and FL scenarios, each containing a Likert-type survey of 18 questions. The REST qualitative version uses an open-ended interview protocol by Brabeck et al. (2000). Response categories for the interview protocol were scored 1-3, with 1 being the lowest level of recognition: (a) no recognition of intolerant behavior; (b) recognition of intolerant behavior; and (c) recognition of intolerant behavior, elaboration of the implications, sensitivity, and complexity of issues within the context depicted in the scenario (Brabeck et al., 2000). Both quantitative and qualitative assessment strategies were used in this study. The following is a brief synopsis of the BP and FL scenarios:

> Basketball Practice: A Black student enters the gymnasium a few minutes late for practice and is chewed out by the coach in front of the team. Being made to run extra laps then punishes him. Meanwhile, a White student is sitting on the bleachers making out with his girlfriend and ends up being even later that the first student, in addition to being out of uniform. The coach chides him for being a "stud" and does not make him do laps, and then tells the White student that Black students keep "guys like you" out of school. Later, the Black student complains to his guidance counselor about the racist behavior of the coach. His counselor minimizes the problem and tells him to stick it out, stating that he needs basketball to get into college. This is despite the fact that the student is on the honor roll.
>
> Faculty Lounge: Two teachers are discussing a student in front of a new faculty member in the faculty lounge. The two veteran teachers discuss the student's academic and private life in stereotypical and derogatory ways. They show no concern for the student's privacy and a complete disregard for her

rights to confidentiality. In addition, it is clear that they have no understanding of her culture. When the new faculty member tries to share her thoughts and stand up for the student, she is met with hostility and ridicule (Brabeck et al., 2000, p. 125 - 126).

Simulation Hazelton High at REST

The *Hazelton High at REST* SEG began by Mr. Delaney, a school administrator, greeting a participant outside the science classroom and saying, “So you think you can cut it at Hazelton High? Well, we have a couple of science teacher positions open. I can’t make any promises now; we’ll see how you do in the game scenarios.” This introduction was intended to pique interest and the realism of the SEG. Afterward, participants were free to walk around the science classroom and laboratory preparation areas allowing them to become familiar with Hazelton High. Mr. Delaney reappears and notes, “The game will start when you click on the red button by the door.” Upon clicking the red button, the participant was teleported into the counselor’s office where they are briefed by the school counselor about the BP scenario and told to “Assume you are me….” This instruction was intended to have participants role-play and respond as the professional in the scenario. Mr. Delaney returned twice during the BP scenario and asked what the participant, as the professional, would say to the student in the scenario.

Participants typed their responses to two prompts into a text box on the screen, submitted and the scenario resumed automatically. At the conclusion, the participant answered 18 survey questions and “walked” back through the laboratory preparation area, clicked the black button to begin the FL scenario. Similar to the BP scenario, a new teacher greeted the participant, introduced the FL scenario and said, “Assume you are me the new teacher.” Participants typed their responses to three prompts during the FL scenario. At the conclusion, participants answered another set of 18 survey questions followed by three open-ended prompts about their SEG experience.

Participant Sample and Setting of Study

Recruitment efforts utilized electronic mail to contact secondary science education preservice teachers from eight universities in the mid-Atlantic region for this posttest only research design (Campbell & Stanley, 1963). Thirty-two science teacher candidates responded from three universities located in two states. Testing occurred at participant school sites. Contacts from the remaining universities either did not have secondary science education preservice teachers or did not respond to recruitment requests. The preservice sample contained 22 females and 10 males and the self-reported ethnic composition was: 91% Caucasian, 6% African American and 3% West Indian. Participant ages ranged from 22 – 27 years. Fifty-six percent reported taking classes or workshops for ethics, and/or multicultural issues as part of their professional training, however it was not known whether attendance was voluntary.

Participants were assigned to one of two groups, “V” for participating in the REST video and “S” for participating in the Hazelton High at REST SEG. *Hazelton High at REST* was operational on 15 laptops and accessed through the Internet. Since testing occurred at participant school sites, Internet access became the determining factor for group placement, V or S. Consequently, there were 18 in the V group and 14 in the S group. It is important to note that many students referred to the SEG as a simulation and that is the term we used when quoting student responses.

Data Collection

The procedural sequence for comparison groups V and S are in Table 1. At a decision-making point for the education professional in the scenarios, usually during conversations between virtual characters, the performance-based prompts appeared in a question text box on the screen. Assuming the role of the education professional, participants wrote what they would say in the situation. The scenario proceeded after responses were submitted. All embedded prompt responses, survey responses, and post-game responses were sent electronically and stored on a server then aligned by a unique login created by each participant. A server upgrade during the study resulted in the loss of a small amount of data. Responses were cross-referenced with each other and participant demographic information and analyzed.

Table 1. An overview of the procedural sequence

BP scenario	Scenario	Performance-based assessment	Quick-REST assessment	Post-game prompts
V Group	Watch REST video	N/A	18 BP Likert-type questions	N/A
S Group	Participant in Hazelton High at REST SEG	1. James is very upset and accuses you and administrators of knowing about Coach Nichols, how would you respond to James? 2. How would you counsel James? Write what you would say to him.	18 BP Likert-type questions	1. What was this experience like for you? 2. How might this experience be different from viewing a video? 3. How might these differences affect your responses?
FL scenario	Scenario	Performance-based assessment	Quick-REST assessment	Post-game prompts
V Group	Watch REST video	N/A	18 FL Likert-type questions	N/A
S Group	Participant in Hazelton High at REST SEG	3. How would you respond to the students who made the stereotypic remarks? 4. As Ms. Highland the new teacher, write what you would say (if anything) in response to Mr. Lynch's comment about Latinas? 5. As Ms. Highland the new teacher, what if anything, disturbs you about this conversation?	18 FL Likert-type questions	1. What was this experience like for you? 2. How might this experience be different from viewing a video? 3. How might these differences affect your responses?

Data Analysis

Non-parametric analysis on the validated 36 Likert-type Quick-REST survey was conducted. Non-parametric tests are suitable since we cannot assume a normal distribution with the lower N in this study. The survey was a 5-point scale proceeding from, "I strongly disagree" to "I strongly agree." Ten of 18 questions were reverse-coded for the BP survey and eight of 18 were reversed-coded for the FL survey. Responses from the 36 questions created a score that reflects ethical sensitivity. A high score indicates a more ethically sensitive participant towards issues of racial intolerance in schools (Sirin et al., 2010). Scores were determined using a SPSS syntax provided by the developers of the Quick-REST quantitative measure. The syntax reverse coded the appropriate responses and provided a score for each scenario, BP and FL, then averaged for a final score. The *Mann-Whitney U* determined a difference in Quick-REST scores between the comparison groups, V and S.

Responses to the performance-based assessments were analyzed as recommended by Creswell (2003), notes were written in the margins to “chunk” the topics then coded to distinguish the categories. Responses were coded and grouped utilizing the scoring categories from the REST as “prior themes” (Miles & Huberman, 1994) and were scored a 1 – 3 Ethical Sensitivity Score (EES), 1 being the lowest EES recognition score. Scoring categories of the REST were contingent on recognizing behaviors that violated ethical principles based on professional codes. Table 2 provides six ethical principles based on professional codes of ethics used to develop the REST and have implications of working with individuals from diverse populations. A wide range of behaviors represented the violations. For example in the FL, a teacher portrayed sentiments showing a lack of cultural awareness of his students thus depicting a violation of the ethical principles; professional competence and concern for other’s welfare. Additional behaviors revealed the teacher also lacked self-awareness which, violated ethical principles; integrity, respect for other’s rights, and dignity (Brabeck et al., 2000). Naming the violated ethical principle was not the goal of the assessment. Recognition of the behavior and consideration of the associated complexities were the basis of the scoring categories.

Table 2. Ethical principles based on professional codes

Ethical Principle	Description
Professional Competence	Conduct which brings credit to one's profession, including cultural competence
Integrity	Self-knowledge of professional values, needs, limitations, and the effect of these on one’s work
Professional and Scientific Responsibility	Ethical collaboration with other professionals and holding each to ethical and professional standards
Respect for Other’s Rights and Dignity	Treating others with respect, guarding confidentiality, awareness of individual, cultural and role differences
Concern for Other’s Welfare	Welfare of student is paramount, knowing impact of adverse social, political, and environmental factors
Social Responsibility	Helping others to understand the extent racism can cause suffering and working to improve social policy

Three post-game prompts were analyzed for emergent themes related to the influence of the SEG on participant responses. All responses were read in a recursive manner and organized for further analysis and interpretation. The responses were transformed into frequency counts, called “quantizing” by Miles and Huberman (1994). This facilitated the recognition of patterns and allowed for statistical display of the data.

Results

Survey responses. Participants of the V group had a mean rank score that was significantly higher, p = .01, than the S comparison group, suggesting the V group was more sensitive to racial and gender related ethical violations. A comparison determined if a pattern emerged among the types of questions the V group showed a higher sensitivity for than the S group participants did. A cross-analysis between Quick-REST scores and demographics of the participants showed no discernible pattern emerged in either case. Means, standard deviations, and mean ranks from the *Mann-Whitney U* displayed in Table 3.

Table 3. *Mann-Whitney U* for Quick-REST survey

	N	*M*	*SD*	*Mean Rank*	*Sum of Ranks*	*U*	*P*
V	18	4.27	.39	20.14	362.50		
S	14			11.82	165.50	60.50	.01*

*p<.05, two-tailed.

Performance-based assessments. Scoring categories in Tables 4A-D were contingent on recognizing and understanding the complexity of behaviors in the BP and FL scenarios that violated ethical principles based on professional codes. Table 4E was based on recognizing a major ethical violation. The number of participants were 13 instead of 14 due to a lost of data during a server upgrade.

Table 4A. First BP question

Performance-based assessment	*N*	EES 1 No recognition	EES 2 Recognition	EES 3 Recognition & Complexity
James is very upset and accuses you and administrators of knowing about Coach Nichols, how would you respond?	13	85%	15%	0

The majority of the participant responses did not demonstrate recognition of James' feelings. These responses requested further information without acknowledging James' anger. It is important to note the question told participants how James was feeling. This was also apparent in his tone of voice, his words, and actions depicted in the SEG. The remainder of the responses, 15%, acknowledged James' feelings and requested more information, as evident by this quote, "I am not sure I do know James. Can you share with me what is upsetting you about Coach Nichols?" No responses demonstrated understanding the complexity of biases inherent in the relationship between James, Coach Nicolas and the school administrators nor that the biases might be related to James' feelings.

Table 4B. Second BP question

Performance-based assessment	*N*	EES 1 No recognition	EES 2 Recognition	EES 3 Recognition & Complexity
How would you counsel James? Write what you would say to him.	13	38%	0	62%

This question presented an opportunity to state a plan of action and/or demonstrate an understanding of the complexity of the violations. Approximately two-thirds articulated a plan for counseling James and recognized a need to confront the Coach's behavior. Yet the remaining third justified the Coach's actions and comments by saying, "I understand that Coach Nichols may come off strong at time[s] but I assure you he has your best interest in mind," and "James, Coach sees a lot of potential in you and knows you are a great player. He is just harder on you because he see[s] how great of a player you are." There was a disparity in the proposed plans, 50% of the plans advised James to talk with the Coach "about insensitive remarks" or "point out your feelings to the Coach and tell him how unfairly he is treating you." Whereas 38% of those who offered a plan that involved the assumed role of the education professional to talk to the Coach on James' behalf, "I would tell James that he is valid in feeling the way he does. It is obvious that Coach Nichols show preferences to other players and makes un[in]appropriate comments. I would reassure James of his abilities and his talent. I will call a meeting." A minority of the plans 13%, suggested, "life lessons" as a way to handle Coach's behavior, "Keep perspective on what is important…don't allow actions of Coach Nichols to interfere with potential. Don't quit; rise above."

Table 4C. First FL question

Performance-based assessment	*N*	EES 1 No recognition	EES 2 Recognition	EES 3 Recognition & Complexity
How would you respond to the students who made stereotypic remarks?	13	0	31%	69%

The majority, 69%, of the participants classified the remarks as "biased," "prejudiced," "stereotypical," or "racist," and suggested a plan. A typical response was, "There is no place that is appropriate for that type of statement. Using stereotypical remarks like that will not be tolerated in this classroom (the student would be referred to the counselor.)" The remainder of the responses recognized the remarks as "inappropriate" and "those remarks have no place in my school" however they did not go further and suggest a plan or demonstrate understanding of the complexity in the situation.

Table 4D. Second FL question

Performance-based assessment	*N*	EES 1 No recognition	EES 2 Recognition	EES 3 Recognition & Complexity
As Ms. Highland the new teacher, write what you would say (if anything) in response to Mr. Lynch's comment about Latinas?	13	16%*	84%	0

*All responded similarly, "I wouldn't say anything unless spoken to."

From the perspective of a new teacher, 16% would not respond to the comments about Latinas. The position to "not say anything" taken by several participants needs attention. Note that unknown political climates in school cultures can be a hindrance in recognizing a need for professional judgment. The majority labeled the remarks as "generalizations" or "assumptions," one stated, "I would say that you make an assumption about all Latin American girls based on the actions of one?" However no one acknowledged the complexity or possible impact of Mr. Lynch's comments about Latinas.

Table 4E. Third FL question

Performance-based assessment	*N*	Recognition of major violations			
As Ms. Highland the new teacher, what, if anything, disturbs you about this conversation?	13	Confidentiality 8%	Cultural awareness 62%	Professional treatment 15%	Self awareness 15%

This question was used to unearth the major violation in the FL scenario, confidentiality (Brabeck et al., 2000). A majority, 62%, of the participants said, teachers in the FL were "…talking so horribly about different races," and they "…have many preconceived notions about Latinas" suggest that cultural awareness was their major disturbance in the scenario. One or more of the characters in the FL scenario violated all six ethical principles (Table 2), however all violations occurred in a public forum thereby violating the student's right to privacy as noted by this quote, "It is disturbing to me that confidential information about a student is being made public."

Post-SEG prompts. Analysis focused on the influence of *Hazelton High at REST* on participant responses. When asked, *what was this experience like for you?* Over 64% described a reflective and enjoyable component in their experience similar to this quote,

> This was a good experience for me. I feel as if cultural sensitivity issues do not come up in education as often as they should because people feel it is a difficult topic to discuss. I was happy to be exposed to the topic through the simulations.

The remainders were a critique of the SEG scenarios however the majority was positive, for example, "I enjoyed the simulation because it was very technological based." Interaction was the focus when asked how the SEG might differ from watching a video. Seventy-one percent thought the interaction was helpful, as identified by these quotes, "…I can walk through the rooms and explore things unlike if I was to sit and watch a video…this was a more active experience for me," and "…I feel like I as at the school and I directly impacted what was happening at the school." For 7% of the participants, the amount of interaction were a distraction or not enough to be helpful, "sometimes you were wondering what to do next." In the final question, *how might these differences affect your responses?* Comments again pointed to reflection. These quotes represent 66% of the responses, "I thought more about what happened and examined my own reactions more closely," and "I might empathize better because I can feel what it's like to be in the room." Twenty percent of the responses reflected on how they reacted during the SEG, it "Made me feel like I was in the room, more a part of the experience," and "Perhaps if I were to watch a video, my responses would be characterized as ones of a "judge", and not necessary as my personal ones."

> Watching a video could make your responses bias because you have not been confronted with an actual scenario. By participating in a simulation, I felt more motivated to give the response I think I would say, not just what I know I should say.

Re-evaluation

In response to the above comments, there was a re-examination of participant responses. The total number of responses was analyzed for emergent themes versus separating them by question as in the earlier analysis. In addition, the above comments enticed the researchers to consider the SEG as providing more realistic performance outcomes possibly because they were immersed in the SEG. Two researchers independently read all responses and organized them for coding. An initial face-to-face meeting to compare results and determine interrater agreement showed coding themes was almost identical and rater agreement was 88% for 42 responses. Discrepancies were discussed and final interrater agreement was 100%.

Emergent themes were: (a) no difference, (b) technology or user issues, (c) like video better, (d) immersion, realistic and/or interaction (e) enjoyed, (f) reflective, and (g) Hawthorne. The Hawthorne theme was responses that noted being a part of an assessment, for example, "…less involvement might skew my extreme responses (strongly agree/strongly disagree) to a milder response." Out of 42 responses the following four themes received the highest frequencies; (a) interaction 36%, (b) reflection 33%, (c) enjoyed 21%, and (d) Hawthorne 19%.

Discussion and Implications

The V group had a significantly higher mean rank Quick-REST score than the S group suggesting the V group was more ethically sensitive at the time of the investigation. Overall, analysis of performance-based assessment questions indicated no recognition of ethical violations was the most frequent response given by the S group. Recognition of ethical violations and showing complexity of the issue was the second most frequent response and recognition of ethical violations was the least frequent response. These findings suggest the SEG provides valuable information concerning candidate disposition when creating equitable learning environments for learners from diverse multicultural and multilinguistic backgrounds.

It was hypothesized that an immersive SEG might affect perspective taking of the participant and indirectly influence ethical sensitivity. Evidence from this study indicates some perspective taking occurred, however little evidence shows an effect on ethical sensitivity. What does seem evident from this study is the use of the SEG as a diagnostic or training tool during the professional education program. Studies have shown ethical sensitivity skills are not improved through conventional professional education (Bebeau & Monson, 2008), yet can be with specific ethical skills education related to the profession (Bebeau & Monson, 2008; Bebeau et al., 1985; Clarkeburn, 2002). The SEG required participants to produce a response instead of choosing a response. This allows analysis of problem-solving skills and reveals individual areas of needed remediation.

Reactions to the SEG indicated an enjoyable, reflective environment that was interactive and allowed some participants to respond more realistically. Fifty-seven percent of the participants made both reflective and immersive comments as apparent by this quote, "it proposes interesting questions and situations that are complicated and thought provoking" and "the interaction makes you feel part of the situation...makes you feel there in the school itself." "Giving responses within the game allows for real time responses and feelings in the moment," suggests there is interplay between the immersive qualities and the reflective nature of the virtual environment affecting the ability to provide responses that are more realistic. As these quotes indicate, the SEG was more than intermittent questions strategically placed. It was the SEG in total, the context, immersive qualities, interaction, and producing responses in the moment to which the participants were responding. The relationship between reflection and immersion suggests the virtual environment revealed realistic performance outcomes, in effect mitigating the Hawthorne effect for some participants. However, seven percent of the responses stated "frustration" or an inability to "know what to do next." Lee, Plass, and Homer (2006) cautions designers and remind them to consider the cognitive load requirements necessary for processing images and concepts not visual to the human eye (Reigeluth & Schwartz, 1989) especially for the novice gamer. This type of inefficacy and possible deterrent to performance-assessment is an area of future exploration. Strides in determining how simulated environments affect learning are difficult and further research in this area is needed (Baek, 2009).

The use of Serious Educational Games (Annetta, 2008) for professional performance-based assessments is a new frontier in education following in the footsteps of the military and medical fields. Science education programs and researchers have the ability to track participant actions and note patterns which maybe instrumental in determining skill level, areas of needed remediation or refinement of skills. This investigation merges specific characteristics designed into *Hazleton High at REST* while pursuing realistic performance outcomes. Equally important, this study explores science teacher ethical sensitivity for racial and gender intolerant behavior in schools where unconscious biases can be examined. The aim was to gain insight into the problem solving skills of preservice science teachers when confronted with racial and gender intolerant behavior in a classroom. The scenarios were a close approximation of what the participant might encounter in real life in a risk-free computer simulated environment. The responses in the role-playing situations allowed participants to reflect and apply their knowledge in an appropriate manner to authentic information. These attributes are several of the basic design features for simulations noted for effectiveness by Magee (2006).

Recommendations for Future Research and Conclusion

Future researchers should analyze preservice teacher behavior using a mixture of surveys and performance-based assessments in an immersive and engaging environment that mirrors real life teaching settings. Furthermore, researchers should also examine challenges in user-interface, usability, and cognitive-load experienced by those who utilize SEGs and other performance based assessments. Even with known challenges, a well-designed SEG has the potential to improve participant skills and critical thinking in a complex authentic context while moving beyond multiple-choice assessments.

Set forth by science education professional standards, science educators are to develop and demonstrate knowledge of diverse cultures, relate science to the stakeholders in the community, value cultural heritage, and respect learner worldview when selecting and developing lessons (AAAS, 1989; CAEP 2012; NSTA 2012). Demonstrating these responsibilities may appear daunting in today's multicultural and multilinguistic learning environments. Expressing cultural knowledge of K-12 learners and respecting their cultural heritage and identity can be challenging due to unfamiliarity with cultural backgrounds, unsubstantiated beliefs about the other, and the rapid change in learner demographics (Welton & Martinez, 2014). A risk-free SEG or simulation may allow novice teachers to feel a part of the environment and perform a desired skill that closely matches their true capabilities and promote culturally-responsive science education.

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Sexual Health Knowledge of Teachers

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Abstract

The aim of this study is to investigate the knowledge level of teachers regarding sexual health. The sample of the study consists of 462 teachers working at primary, middle and high schools in Turkey. As the study aims to determine the current status of teachers regarding sexual health knowledge, the relational screening model was used. The Cronbach's Alpha correlation coefficient was calculated and determined to be 0.782. t test and ANOVA were used for data analysis. The "Sexual Health Knowledge Scale" used within the scope of the sexual health course is a 5-point Likert scale and the possible score from the scale varies from 1 to 5. It is possible to say that the teachers had a high knowledge level regarding sexual health. Analysis showed that female teachers had a significantly higher knowledge level compared to male teachers, married teachers had a significantly higher knowledge level compared to single teachers, teachers who took the Sexual Health course during their undergraduate studies had a significantly higher knowledge level compared to teachers who did not, and teachers who received education regarding sexual health had a significantly higher knowledge level compared to teachers who did not.
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Introduction

In Turkey, sexuality is usually a taboo subject which is ignored and not discussed. As a result, terms related to sexuality seem to be not well known and often incorrectly used. Therefore, it should be useful to review some basic terms related to sexuality prior to examine the subject of sexual education. Sexual identity refers to information related to one's own biological sex and also the ability to distinguish the biological sex of another person, which is in the same category (Vatandaş, 2011). Sexual role or gender, on the other hand, refers to behavior patterns which the society deems appropriate for a man or woman (Bayhan and Artan, 2004).

Sexuality has two basic functions. The first is to experience sexual satisfaction, and the second is reproduction (Önder, 2006). Today's Turkey host cultures which suppress sexuality, cultures which limit sexuality, and also cultures which allow sexuality. In other words, the understanding of sexuality struggles between Eastern and Western cultures, and it is possible to find sexual life styles from bigoted rules of the Middle Age to tremendously free sexual behaviors. In addition to providing women with equal rights upon its foundation, the Republic of Turkey aimed to provide women with equal opportunities in education and professional life as well. However, it has not been possible to reach the desired level of equality between men and women in economy, politics, or sexual life to this day (Poroy, 2005, as cited in Çalışandemir, Bencik, and Artan, 2008).

Different cultures may have different perceptions of sexuality, while different individuals within the same society may have different perceptions of sexuality, which is natural. The following three basic sexual culture types may be seen in the society due to different perceptions of sexuality. The first type involves cultures that suppress sexuality. In such cultures, the sole purpose of sexuality is reproduction. Sexually is or should be prevented if partners do not want children. The youth are not informed about sexuality. Extramarital intercourse is prohibited.

Friendship between opposite sexes is not taken kindly in the second type, which involves cultures that limit sexuality. One of the sexes is allowed to have extramarital sex, while the other is not. Discrepancies cause fear and inevitability related to sexuality. Sexuality is frowned upon in cultures that allow sexuality, the third type. However, sexuality does not cause any strong reactions as long as it is not in sight. Friendship between opposite sexes is allowed and perceived to be normal. Extramarital intercourse may be tolerated. Instead of discussing whether sexual intercourse occurred or not, such cultures discuss what behavior is right and what behavior is wrong as far as sexuality goes (Fincanoğlu and Bulut, 2003).

Sexual health education is a process of life-long knowledge acquisition, creating value, stance and belief about identity, relationships and privacy (SIECUS, 2006).Sexual health is one's ability to express one's sexuality without risks related to sexually transmitted infections, unwanted pregnancies, being forced, violence, and discrimination (CSÜS, 2005). It is a human being's well-being as a sexual being which enhances not only physical, but also emotional, intellectual, and social integrity. It contributes to the development of personality, improves communication, and allows for sharing love (Önder, 2006). Sexual health is a natural, healthy, and indispensable part of one's life (CSB textbook). Sexuality is also addressed within the scope of basic human rights. The basic rights related to sexuality and reproduction are as follows (Önder, 2006):

1. One's life should not be endangered due to reproduction and sexuality.
2. One should be able to maintain one's reproductive and sexual life without being subject to pressure or violence.
3. Everyone should have access to reproductive health services equally without discriminating between the wealthy and the poor, the urban and the rural, or men and women.
4. One should be able to live one's sexual life in line with their sexual identity and orientations in privacy and freedom.
5. One should be able to express one's ideas regarding sexuality freely.
6. One should have access to education and right information regarding reproductive and sexual health.
7. One should be able to make one's decision regarding marriage freely without being subject to pressure and violence.
8. One should be able to make one's decision regarding when and how many children one wishes to have.
9. One should be able to receive necessary service from health institutions for protection of reproductive and sexual health.
10. One should be able to benefit from scientific studies to protect and improve reproductive and sexual health.
11. One should not be subjected to maltreatment, violence, abuse, or torture due to one's sexuality.

Sexual problems prevent individuals from reaching their expectations related to their personal sex lives. Some sexual health problems include lack of sexual drive, sexual arousal disorders, vaginismus, congenital (genetic) disorders, and sexually transmitted diseases. Precautions to avoid sexually transmitted diseases may be listed as follows: Monogamy is very important. However, both partners must be monogamous for proper protection. Condoms should be used in any kind of sexual intercourse. Condom use is the most significant method to avoid pregnancies and sexually transmitted diseases.

Sexual health involves a positive and respectful approach to sexuality and sexual intercourses. It is necessary to protect and maintain sexual health, to respect sexual rights of all individuals in order to maintain these. (PHAC, 2008). While sexual health is an important concept in all periods of one's life, it is particularly important during adolescence. Individuals are more curious about sexuality, do more research, and shape their behaviors and attitudes related to sexuality during adolescence, thus they need correct information the most in this period. It is very important to communicate in a friendly manner with and gain trust of adolescents (Ergün and Çakır, 2015). Sexual education practices have been included in the agenda of formal educational institutions in many countries with the idea that lack of knowledge related to sexuality increases the risk faced by adolescents (Güler and Yöndem, 2007).

Sexual education is not limited to names of body parts, their functions, reproduction and similar. The true purpose of sexual education is to ensure one understands one's physical, emotional, and sexual development, develops a positive conception of personality, and acquires respect towards rights, ideas, and behaviors of others (Bilen and Topçuoğlu, 2008). Sexual education starts in the family and continues throughout one's life. Studies report that a negative approach adopted in family environment can be partially changed through education (Ergün and Çakır, 2015).

Similar to many other countries, sexuality remains an implicit subject and sexual education, services, and research are limited in Turkey (Set, Dağdeviren, and Aktürk, 2006). Education is not the only responsibility of a teacher. The teacher must also assume the role of a leader for the entire society. As the person who adolescent students and their parents will come to consult, the teacher must have sufficient knowledge related to sexual health in order to inform and guide students and parents correctly and appropriately so that sexuality does not remain an implicit subject as stated by Set et al. (2006). Similarly, the teacher must be active in sexual health education according to Bulut, Nalbant, and Çokar (2002). To this end, he or she must have sufficient sexual health knowledge first as an individual and then as a teacher.

The purpose of this study is to investigate knowledge levels of teachers regarding sexual health. In this context, the study seeks to answer the following questions:

1. What birth control methods do teachers use?
2. What sources do teachers use to learn about sexual health?
3. What is the knowledge level of teachers regarding sexual health?
4. Does the knowledge level of teachers change depending on a) Sex, b) Marital status, c) Sexual activity status, d) Age, e) The level they teach, f) Whether or not they took the sexual health course, g) Whether or not they received education regarding sexual health?

Method

Research Model

As the study aims to determine the current status of teachers regarding sexual health knowledge, the relational screening model was used. The relational screening model aims to describe the current status as is. The individual, the object or the event, which is the subject of the study, is defined under its own conditions and as is without an intention to intervene (Karasar, 2004).

Sample

Electronic version of the scale was shared in social media groups such as teacher groups, graduate groups etc. Even though it is unknown how many people refused to participate in the study, 462 teachers accepted to participate the study voluntarily. Therefore, the sample of the study consists of 462 primary, secondary and high school teachers working in 42 provinces of Turkey.

Table 1. The distribution of teachers by the region where they work

	n	%
Mediterranean Region	26	5.63
Aegean Region	29	6.28
Eastern Anatolia Region	63	13.64
Central Anatolia Region	133	28.79
Marmara Region	115	24.89
Southeastern Anatolia Region	31	6.71
Black Sea Region	65	14.07
Total	462	100

Table 1 shows the distribution of teachers by the region where they work in percentage and frequency. Table 1 shows that the Central Anatolia Region was in the first place with 133 (28.79%) teachers, followed by the Mediterranean Region with 26 (5.63%) teachers.

Table 2. The distribution of teachers by variables of sex, marital status, sexual activity status in percentage and frequency

		n	%		n	%	Sexually active	n	%
Sex	Female	296	64.07	married	105	22.73	yes	105	22.73
							no	0	0.00
				single	191	41.34	yes	52	11.26
							no	139	30.09
	Male	166	35.93	married	66	14.29	yes	66	14.29
							no	0	0.00
				single	100	21.65	yes	62	13.42
							no	38	8.23

Table 2 shows the distribution of teachers by variables of sex, marital status, and sexual activity status in percentage and frequency. As shown in Table 2, all married teachers had sexual intercourse experience. However, among single teachers, 139 female teachers and 38 male teachers had no sexual intercourse experience.

Data Collection Tool

The scale used to collect data consists of two parts. The first part includes voluntary participation form and questions to determine personal characteristics of the participants. Within the sexual health information lecture given by Erten; scale of "Sexual Health Information" developed with content validity, validity and credibility studies consists of 20 items in total. It is a 5-point Likert scale and the possible score from the scale varies from 1 to 5. Cronbach's Alpha correlation coefficient of the scale was calculated within the scope of the study and found to be 0.782.

Data Collection

Data was collected concerning the share of scale's electronic version in the social media groups such as teachers, teacher groups, and graduate groups in Turkey. Teachers were not asked for information such as name, last name, or school's name, which would reveal their identity.

Data Analysis

Findings regarding personal characteristics of the participants were analyzed using percentage and frequency. Resulting percentage values were used to determine the distribution of personal characteristics of the participants, whereas frequency values were used to interpret personal characteristics. It is a 5-point Likert scale and the possible score from the scale varies from 1 to 5. The following classification is obtained from the 5-point Likert scale: 1.00-1.80 : Very low knowledge level, 1.81-2.60 : Low knowledge level, 2.61-3.40 : Moderate knowledge level, 3.41-4.20 : High knowledge level, 4.21-5.00 : Very high knowledge level. The knowledge level of teachers regarding sexual health was interpreted based on this classification. The independent samples t test was used to compare two groups, whereas the one-way analysis of variance (ANOVA) was used to compare more than two groups.

Findings

This section presents findings obtained as a result of data analysis. Table 3 shows birth control methods used by 119 out of 285 teachers with sexual intercourse experience. 36.18% of the teachers who reported more than one birth control method used "condom (male)". Among unreliable methods, the "withdrawal" method was used by 29.65% of the teachers, while the "calendar method" was used by 6.53% of the teachers. Also, 6.03% of the teachers used the "morning-after pill", which is not a birth control method.

Table 3. Birth control methods used by teachers

Birth Control Method	n	%
Condom (male)	72	36.18
Withdrawal	59	29.65
Contraceptive pill	29	14.57
Calendar method	13	6.53
Morning-after pill	12	6.03
Intrauterine device	10	5.03
Contraceptive injection	3	1.51
Condom (female)	1	0.50

The sources used by the teachers, who reported more than one source, can be seen in Table 4. The most commonly used source for information regarding sexual health was written sources (78.79%) and friends (76.20%).

Table 4. Sources used by teachers to learn about sexual health

Source	n	%
Written sources	364	78.79
Friends	352	76.20
Mother	87	18.83
Other (Personal experiences, movies, relatives, partner, teacher, etc.)	78	16.88
Spouse	60	12.99
Sibling	39	8.44
Father	26	5.63

Table 5 shows the average knowledge level of the teachers regarding sexual health. The average knowledge level of 462 teachers was found to be 3.78. It can be said based on this finding that the teachers had a high knowledge level regarding sexual health.

Table 5. The knowledge level of teachers regarding sexual health

n	$\bar{X}$	Ss
462	3.78	0.44

Table 6 shows the analysis of the knowledge level of the teachers regarding sexual health by the sex variable. 296 of the teachers were female and 166 were male. It can be said that both female teachers ($\bar{X}$ =3.81) and male teachers ($\bar{X}$ =3.72) had a "high" knowledge level regarding sexual health. t test was used to analyze whether the knowledge level of the teachers regarding sexual health varied depending on sex. As a result of the analysis, female teachers were found to have a higher knowledge level compared to male teachers.

Table 6. The analysis of the knowledge level of the teachers regarding sexual health by the sex variable

Sex	n	%	$\bar{X}$	ss	t	sd	p
Female	296	64.07	3.81	0.42	185.94	461.00	0.00*
Male	166	35.93	3.72	0.46			
TOTAL	462	100.00	3.78	0.44			

$p<0.05$

Table 7 shows the analysis of the knowledge level of the teachers regarding sexual health by the marital status variable. 171 teachers were married and 291 were single. It can be said that both married teachers ($\bar{X}$ =3.80) and single teachers ($\bar{X}$ =3.77) had a "high" knowledge level regarding sexual health. t test was used to analyze whether the knowledge level of the teachers regarding sexual health varied depending on marital status. As a result of the analysis, married teachers were found to have a higher knowledge level compared to single teachers.

Table 7. The analysis of the knowledge level of the teachers regarding sexual health by the marital status variable

Marital status	n	%	$\bar{X}$	ss	t	Sd	p
Married	171	37.01	3.80	0.42	185.94	461.00	0.00*
Single	291	62.99	3.77	0.45			
TOTAL	462	100.00	3.78	0.44			

$p<0.05$

Table 8 shows the analysis of the knowledge level of the teachers regarding sexual health by the sexual intercourse experience variable. 285 teachers had sexual intercourse experience and 177 had no sexual intercourse experience. It can be said that both teachers with sexual intercourse experience ($\bar{X}$ =3.82) and teachers with no sexual intercourse experience ($\bar{X}$ =3.71) had a "high" knowledge level regarding sexual health. t test was used to analyze whether the knowledge level of the teachers regarding sexual health varied depending on sexual intercourse experience. As a result of the analysis, teachers with sexual intercourse experience were found to have a higher knowledge level compared to teachers with no sexual intercourse experience.

Table 8. The analysis of the knowledge level of the teachers regarding sexual health by the sexual intercourse experience variable

Sexual Intercourse Experience	n	%	$\bar{x}$	ss	t	sd	p
Yes	285	61.69	3.82	0.43	47.11	461.00	0.00*
No	177	38.32	3.71	0.44			
TOTAL	462	100.00	3.78	0.44			

p<0.05

Table 9 shows the average knowledge level of the teachers regarding sexual health by the age variable. Teachers in the 36-40 age group had the highest knowledge level regarding sexual health level with 3.95 points. Teachers in the 41 and above age group had the lowest knowledge level regarding sexual health level with 3.64 points. It can be said that the teachers in all age groups had a high knowledge level regarding sexual health.

Table 9. The average knowledge level of the teachers regarding sexual health by the age variable

Age	n	%	$\bar{x}$	Ss
25 and below	180	38.96	3.79	0.45
26-30	202	43.72	3.74	0.44
31-35	41	8.87	3.91	0.32
36-40	21	4.55	3.95	0.33
41 and above	18	3.90	3.64	0.51
TOTAL	462	100.00	3.78	0.44

One-way analysis of variance was used to analyze whether the knowledge level of the teachers regarding sexual health varied depending on age. According to the analysis of variance, the knowledge level of the teachers regarding sexual health varied depending on age. Paired comparisons were made between the groups to reveal the source of variances. The LSD comparison test showed that the teachers in the 41 and above age group had a significantly lower knowledge level regarding sexual health compared to teachers in all other groups.

Table 10. ANOVA results pertaining to the relationship between the knowledge level of teachers regarding sexual health and the age variable

Source of Variance	Sum Of Squares	sd	Variance	F	p
Between the groups	2.99	6.00	0.50	2.67	0.01*
Within the group	84.91	455.00	0.19		
TOTAL	87.91	462.00			

p<0.05

Table 11 shows the average knowledge level of the teachers regarding sexual health by the level they teach. High school teachers had the highest knowledge level regarding sexual health level with 3.82 points. Primary school teachers had the lowest knowledge level regarding sexual health level with 3.74 points.

Table 11. The average knowledge level of the teachers regarding sexual health by the level they teach

Level	n	%	$\bar{x}$	ss
Primary school	191	41.34	3.74	0.44
Middle school	169	36.58	3.81	0.44
High school	57	12.34	3.82	0.43
Not reported	45	9.74	3.75	0.39
TOTAL	462	100.00	3.78	0.44

One-way analysis of variance was used to analyze whether the knowledge level of the teachers regarding sexual health varied depending on the level they teach. According to the analysis of variance, the knowledge level of the teachers regarding sexual health did not vary depending on the level they teach.

Table 12. ANOVA results pertaining to the relationship between the knowledge level of teachers regarding sexual health and the level they teach

Source of Variance	Sum Of Squares	sd	Variance	F	p
Between the groups	0.55	3.00	0.18	0.96	0.41
Within the group	87.35	458.00	0.19		
TOTAL	87.91	462.00			

$p<0.05$

Table 13 shows the analysis of the knowledge level of the teachers regarding sexual health by whether or not they took the sexual health course during their undergraduate studies. 130 teachers took the course and 332 did not. It can be said that both teachers who took the course ($\bar{X}$ =3.93) and teachers who did not take the course ($\bar{X}$ =3.72) had a "high" knowledge level regarding sexual health. T test was used to analyze whether the knowledge level of the teachers regarding sexual health varied depending on whether or not they took the sexual health course during their undergraduate studies. As a result of the analysis, teachers who took the course were found to have a higher knowledge level compared to teachers who did not.

Table 13. The analysis of the knowledge level of the teachers regarding sexual health by whether or not they took the sexual health course during their undergraduate studies

Took the sexual health course	n	%	$\bar{X}$	ss	t	sd	p
Yes	130	28.14	3.93	0.45	185.94	461.00	0.00*
No	332	71.86	3.72	0.42			
TOTAL	462	100.00	3.78	0.44			

$p<0.05$

Table 14 shows the analysis of the knowledge level of the teachers regarding sexual health by whether or not they received education regarding sexual health. 127 received education and 335 did not. It can be said that both teachers who received education ($\bar{X}$ =3.99) and teachers who did not receive education ($\bar{X}$ =3.70) had a "high" knowledge level regarding sexual health. T test was used to analyze whether the knowledge level of the teachers regarding sexual health varied depending on whether or not they received education.

Table 14. The analysis of the knowledge level of the teachers regarding sexual health by whether or not they received education regarding sexual health

Received education regarding sexual health	n	%	$\bar{X}$	ss	t	sd	p
Yes	127	27.49	3.99	0.38	185.94	461.00	0.00*
No	335	72.51	3.70	0.43			
TOTAL	462	100.00	3.78	0.44			

$p<0.05$

As a result of the analysis, teachers who received education were found to have a higher knowledge level compared to teachers who did not. The teachers who reported that they had received education regarding sexual health were asked "Where and when did you receive education regarding sexual health? Who/what institution gave the education?". The answers included "Middle School Sexual Health Course, In-service Educational Seminars, Educational Programs held by University Health Centers, AÇEV (Mother and Child Education Foundation), Courses within the scope of Support for Mothers Program, and Educational Seminars held by TOG (Community Volunteers Foundation)".

Discussion

36.18% of 119 teachers who reported more than one birth control method used "condom (male)". Among unreliable methods, the "withdrawal" method was used by 29.65% of the teachers, while the "calendar method" was used by 6.53% of the teachers. Also, 6.03% of the teachers used the "morning-after pill", which is not a birth control method. It was observed that the teachers who were found to have a "high" knowledge level regarding sexual health were not able to use their knowledge in their own lives.

For 462 teachers who reported more than one source, the most commonly used source for information regarding sexual health was written sources (78.79%) and friends (76.20%). Kaya, Serin, and Genç (2007) conducted a study to reveal approaches of prospective teachers in faculty of education regarding sexual life and examined whether they talked to their families about topics related to sexuality. 18.5% of 170 female prospective teachers reported that their families answered their questions regarding sexuality, while 19.7% reported that they could talk with their families about sexuality in detail. Bulut and Ortaylı (2004) found that the main sources of information regarding sexuality were circle of friends and written sources for males. These findings indicate that individuals turn to their friends and written sources for information regarding sexuality because sexual health is not taught in schools and parents avoid the topic in Turkey. This prevents individuals from receiving information from experts, which increases the number of wrong behaviors related to sexuality.

It is possible to say that the teachers in the study had a high knowledge level regarding sexual health with an average of 3.78. However, it should be noted that 28.14% of the teachers took the Sexual Health Course during their undergraduate studies (within the framework of formal education) and 27.49% received informal education regarding sexual health, which positively affected the general knowledge level. It was observed that teachers who took the Sexual Health course (formal education) during their undergraduate studies had a higher knowledge level compared to teachers who did not and teachers who received informal education regarding sexual health had a higher knowledge level compared to teachers who did not. These findings show the effectiveness of a sexual health education from a reliable source. It can be said that both female teachers ($\bar{X}$ =3.81) and male teachers ($\bar{X}$ =3.72) had a "high" knowledge level regarding sexual health. As a result of the analysis, female teachers were found to have a higher knowledge level compared to male teachers.

As a result of the analysis, married teachers were found to have a higher knowledge level compared to single teachers. Also teachers with sexual intercourse experience were found to have a higher knowledge level compared to teachers with no sexual intercourse experience. Siyez and Siyez (2009) performed a study with prospective teachers in faculty of education and examined their knowledge level regarding sexually transmitted diseases. The researchers found that prospective teachers with sexual intercourse experience had a significantly higher knowledge level compared to prospective teachers with no sexual intercourse experience.

Teachers in the 36-40 age group had the highest knowledge level regarding sexual health level with 3.95 points. Teachers in the 41 and above age group had the lowest knowledge level regarding sexual health level with 3.64 points. It can be said that the teachers in all age groups had a high knowledge level regarding sexual health. However, analysis showed that the teachers in the 41 and above age group had a significantly lower knowledge level regarding sexual health compared to teachers in all other groups. High school teachers had the highest knowledge level regarding sexual health level with 3.82 points. Primary school teachers had the lowest knowledge level regarding sexual health level with 3.74 points. It can be said that the teachers working at all educational levels had a high knowledge level regarding sexual health. Also, the knowledge level of the teachers regarding sexual health did not vary depending on the level they teach.

Conclusion and Recommendations

It is possible to say that there are three different approaches toward sexuality in Turkey: "suppressing, limiting, and allowing". Considering that men are positively discriminated in these approaches, it is interesting that women have a higher knowledge level regarding sexual health compared to men. This may be due to men's not being able talk about sexual health among each other, fear of being mocked, or not being able to admit their lack of knowledge. Sexual health educations held by medical centers are mostly aimed at women. Educations aimed specifically at men may be useful to increase the knowledge level of men. As a result of the analysis, married teachers and teachers with sexual intercourse experience were found to have a significantly higher knowledge level compared to single teachers and teachers with no sexual intercourse experience. Sexuality or sexual health are not subject that are important for those who are sexually active only, and education programs and information sources should not be prepared for these people only. Sexual health is of great importance for the individual's happiness from birth to death, and it is necessary to provide education to all age groups starting from childhood.

The most commonly reported sources of information regarding sexual health include "friends" and "written sources". However, the knowledge level of friends regarding sexual health is not known. Similarly, it is not known whether written sources have good content and high quality or whether these were prepared by experts or not. As mentioned by Bayrak, Başgül, and Gündüz (2011), all correct and incorrect, useful and harmful, positive and negative impacts related to sexuality are included by the definition of sexual education. For this reason, it is very important to provide the right sexual education. Sexual health education cannot be trusted to friends or written sources, whose sufficiency is not known. Analysis showed that teachers who took the Sexual Health course during their undergraduate studies had a significantly higher knowledge level compared to teachers who did not and teachers who received informal education regarding sexual health had a significantly higher knowledge level compared to teachers who did not. To this end, the "Sexual Health Course" should be encouraged as an elective course in undergraduate programs. Also, education on subject may be provided for teachers within the scope of in-service training. 36.18% of 119 teachers who reported more than one birth control method used "condom (male)". Condom use (male) is a reliable method for protection against sexually transmitted diseases as well as a good birth control method, therefore it is important to encourage condom use. Among unreliable methods, the "withdrawal" method was used by 29.65% of the teachers, while the "calendar method" was used by 6.53% of the teachers. Also, 6.03% of the teachers used the "morning-after pill", which is not a birth control method. It was observed that the teachers who were found to have a "high" knowledge level regarding sexual health were not able to use their knowledge in their own lives. It is necessary to focus on methods used for birth control and protection against sexually transmitted diseases during educations regarding sexual health provided for teachers and they should be encouraged to use these methods in their private lives.

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Environmental Attitude Scale for Secondary School, High School and Undergraduate Students: Validity and Reliability Study

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Abstract

The purpose of this study was to develop a valid and reliable "Environmental Attitude Scale" (EAS) for secondary school (5th, 8th grade), high school (11th) and undergraduate college students. The reliability and validity studies of the scale were carried out in three different countries (Finland, USA and Turkey). The sampling size was 1687 students. For the construct validity, exploratory factor analysis (EFA) was run and in order to test the accuracy of the obtained factor structure. The scale was composed of three sub scales: "Environmental Behaviour Sub Scale (EBSS)", "Environmental Opinion Sub Scale (EOSS)" and "Environmental Emotion Sub Scale (EESS)". The EBSS and EESS consist of two factors each and the EOSS consists of one factor. The EBSS had 13 items, EOSS 11 items and EESS 16 items, all using a 5-point Likert scale. The Cronbach alpha reliability coefficient for the whole scale was found to be α=.94, and reliability coefficient of the first subscale was found to be α=.91, second subscale α=.82 and third subscale α=.94 and the Spearman Brown coefficients were found to be .85, .83, .80 and .85, respectively. Reliability and validity results of the study show that the "Environmental Attitude Scale" can be used to measure the environmental attitudes of the different levels of students.

Introduction

Before designing effective environmental education programs, it is necessary to investigate the variables that are important in the development of environmental literacy. Environmental knowledge, attitudes, and behaviors have been studied in a variety of ways in environmental education and psychology. Milfont and Duckitt (2010) pointed out environmental attitudes as a crucial construct in environmental psychology but there is still lack of knowledge how the same environmental attitudes scales can be used in different countries. Attitudes are a latent construct and as such cannot be observed directly. Thus, rather than being measured directly, attitudes have to be inferred from overt responses (Himmelfarb, 1993). The techniques of attitude measurement can be broadly organized into direct self-report methods and implicit measurement techniques (Krosnick, Judd, & Wittenbrink, 2005). Studies measuring EA have generally used direct self-report methods (e.g., interviews and questionnaires), and much less frequently implicit techniques (e.g., observation, priming and response competition measures) (Milfont and Duckitt, 2010).

Environmental education is a process of clarifying thoughts and values to develop important attitudes and skills for people to understand and appreciate the relations between the culture and bio-physical environment (Palmer, 1998). Palmer (1998) emphasized that students should acquire an appropriate range of knowledge, understanding, and concepts about the environment so that critical judgment can be achieved for one's behavior toward the environment. Further, experiences and reflection in the natural environment should be allowed to refine "environmentally focused skills, … further relevant knowledge, and development of appropriate attitudes and environmental awareness" (p.146). These three components of attitude, knowledge, and awareness, play an important role on students' behaviors throughout their lives inside and outside of classrooms.

Holahan (1982, p.92) described environmental attitudes as "people's favorable feelings toward some feature of the physical environment or toward an issue that pertains to the physical environment". This description includes only favourable aspects. However, should both favourable (positive) and unfavourable (negative) feelings be included, this statement may serve as a basis for a relationship between human beings and the natural environment. Differences in this relationship can be traced to different perspectives regarding whether humans are an integral part of nature, each depending on the other for survival; or whether humans are in some way superior to nature, and hence have the right to dominate and exploit the natural world regardless of the consequences (Ponting, 1991).

Orr (1992) reflected upon the concept of forming attitudes in order to build on ecological literacy. This ecological literacy should not be interpreted as the knowledge of facts and concepts only, but "the knowledge necessary to comprehend interrelatedness, and an attitude of care or stewardship" (p.92). Therefore "knowledge, the attitude of caring, and a practical competence are the basis of an ecological literacy" (Orr, 1990, p.51). Measures of environmental attitudes examine the acceptance of environmental and ecological worldviews (Dunlap, Van Liere, Mertig, & Jones, 2000). Ewert, Place, & Sibthorp (2005) asserted that environmental attitudes are formed in the early stages of one's life.

Many studies have been developed to evaluate these objectives in environmental education by focusing mostly on the levels of knowledge and attitudes in students and children's lives (Keles, 2011; Uzun, 2007, Worsley & Skrzypiec, 1998; Ma & Bateson, 1999; Salmivalli, 1998; Knapp, 1996; Zimmermann, 1996; Malkus, 1992; Musser & Malkus, 1994;). Several instruments have been developed to measure these specific attributes. Among the most common instruments cited in early studies are the Revised Scale for the Measurement of Ecological Attitudes and Knowledge developed by Maloney, Ward, and Braucht (1975), the New Environmental Paradigm (NEP 1978) by Dunlap and Van Liere (1978), the Children's Environmental Attitude and Knowledge Scale (CHEAKS) by Leeming, Bracken, and Dwyer (1995), and the revised NEP scale the New Ecological Paradigm (NEP, 2000) Scale by Dunlap, Van Liere, Mertig, and Jones (2000), and the development and validation of an environmental attitudes scale for high school students by Uzun and Sağlam (2006). Some studies focus on attitudes regarding factors that may influence an adults' positive, negative, or neutral attitude toward environmental issues. These studies often include possible relationships between attitudes toward the environment and interventions such as environmental education, or, attitudes and a persons' gender, background, religion, ethnicity, or education (Bögeholz, 2006; Ewert, Place, & Sibthorp, 2005; Murphy, 2004; Franzen, 2003; Hodgkinson, & Innes, 2001).

In environmental education-related works, it is valuable to measure student attitudes towards the environment and then connect them with other variables and compare them in relation to those other variables (e.g., knowledge). In the related literature, there is a paucity of studies dealing with environmental attitudes at different grade levels. It seems clear that such studies are necessary to measure one's progress of environmental literacy. Hence, we believe that developing a scale to solicit student attitudes about the natural environment will contribute to the field of environmental education and will help to fill this gap in the literature. It is notable that the environmental attitude scales in the literature are mostly comprised of cognitive and behavioral sub-dimensions. However, attitude is made up of emotions, opinions and behaviors related to an object. Emotion is a state of feeling, but it encompasses physiological, cognitive and behavioral components (Solomon, 2008, as cited in Dietrich, 2013).

The experience of negative or positive emotions, may significantly impact not only people's experiences with the environment, but also their tendency to engage in pro-environmental behavior. If one experiences negative emotions, he or she may be less likely to engage in pro-environmental behavior, feeling helpless to engage in meaningful behavior change or to deny the need to change behavior in the first place. Research has identified a number of emotional and affective components of pro-environment behavior (Stern, 2000). For example, Kals, Schumacher, and Montada (1999) developed an "emotional affinity toward nature" scale to identify a construct by which people are connected to nature and express positive feelings with nature. Furthermore, research shows that an emotional bond with nature often serves as a motive to engage in behavior that protects nature (Fisherlehner, 1993, as cited in Kals et al., 1999).

Overall, the studies on the environmental knowledge suggest that adult environmental knowledge is lacking and of concern since basic environmental knowledge is recognized as important for informing or affecting positive environmental attitudes and/or positive environmental behaviors (Fraj-Andrés & Martínez-Salinas, 2007; Frick, Kaiser & Wilson, 2004). Several studies have found a positive but weak association between: increased environmental knowledge, a positive environmental attitude, and behavior changes to protect the environment (Coyle, 2005).

As can be understood from the revised literature cited above, the determination of attitudes towards environment is a function of opinions as well as the construction of knowledge, emotions and by increasing one's motivation towards the protection of environment. This approach can affect positive behaviors which can be of vital importance. Accordingly, all of these components play important roles in creating individuals with environmental awareness. These components should not be addressed separately. Thus, this study aimed to develop a new scale by adding an affective dimension to the scale made up of two environment-related dimensions. When this three-dimensional structure of attitude is considered, it is seen that a majority of the scales developed in the literature lack the affective dimension. Therefore, the aim of this study was to develop a valid and reliable scale to determine the attitudes of secondary school, high school and university students towards the environment. Further, it was tested in three different countries: Turkey, The United States, and Finland.

Methods

Piloting

In the development process of the scale, a comprehensive literature review was performed to guide the development of an item pool which was designed by drawing on the items included in the behavior and opinion dimensions of the "Environmental Attitude Scale" developed by Uzun and Sağlam (2006). The linguistic validity of the scale was checked by three academicians specialized in the field of environmental education, whose mother tongues are Turkish, English and Finnish and who have a good command of at least two of these languages. An expert on translation checked the accuracy of the translations made from Turkish to English and Finnish (Appendix). With the help of three experts who are specialized in environmental education, 47 (13 behavior, 14 opinion and 20 emotion items) 5-point Likert type items were taken from the item pool and piloted among 486 students from secondary schools, high schools and undergraduate college students at the University of Aksaray, Turkey. At the end of the analysis, two items with an item-total correlation value lower than .30 were discarded from the scale and the final form of the scale with 45 items was obtained.

Study Group

Reliability and validity of the Environmental Attitude Scale were conducted in Finland (256 students), USA (616 students) and Turkey (807 students). Out of 1687 students participating in the study, 402 (23.8%) were students in fifth grade, 275 (16.3%) were in eighth grade, 612 (36.3%) in eleventh grade and 383 (22.7%) were undergraduate college students. 904 (53.6%) of the students were girls and 762 (45.2%) were boys. Using a "cluster sampling" method, one class from each grade level (5^{th}, 8^{th}, 11^{th} and college undergraduate) from each school was randomly selected and involved in the study. In order to establish a match between the grade levels from the three countries, 11^{th} grade students were excluded from the study.

Statistical Analysis

The data obtained from the scale were analyzed through SPSS (Statistical Package for the Social Sciences). Data were deemed suitable for factor analysis by using the Kaiser-Meyer-Olkin (KMO) coefficient and the Bartlett Sphericity test (Büyüköztürk, 2005). In order to test the construct validity and factor structure of the Environmental Attitude Scale, an exploratory factor analysis was used. Finally, a principle components analysis (PCA) was used. In the analyses, common factor variance of the factors on each variable, factor loadings of the items, explained variance ratios and a scree plot were examined. The factor loading of the items was determined to be at least .30. Factor loading over .30 is considered to be acceptable (Büyüköztürk, 2005). In order to examine the factor structures, a varimax principle components analysis was conducted. In order to determine the connection of the scales with the factors and factors with each other, a Pearson correlation coefficient was used. The reliability analysis was carried out by calculating item-total correlation using Cronbach's alpha internal consistency and Spearman Brown coefficients.The Environmental Attitude Scale was evaluated by looking at the responses given to the positive items as 5: Strongly agree/Always, 4: Agree/Often, 3: Partially agree/Sometimes, 2: Disagree/Rarely and 1: Strongly disagree/Never and reversing the scoring from 1 to 5 for the negative items. As a result, an environmental attitude score was obtained for each student. From the reliability measures and factor analysis, 5 of the 45 items were discarded. The scale was then evaluated over 40 items. Therefore, the lowest score to be obtained from the scale is 40 and the highest is 200.

Findings

In this section, results of the normality belonging to the EBSS, EOSS and EESS**,** reliability and validity works are presented.

Normality Belonging to the EBSS, EOSS and EESS

One of the prerequisites to conduct comparative parametric tests such as t-test, variance analysis etc. is the normal distribution of the data (Büyüköztürk, 2005). A Skewness and Kurtosis coefficient being "0" means complete symmetric distribution according to the mean. Skewness and Kurtosis being between -1 and +1 means that the scores do not show significant deviance from the normal distribution (Büyüköztürk, 2005). In the analysis, Skewness coefficients of the scores were calculated to be .110, -.748 and -.829, respectively and Kurtosis coefficients of the scores were calculated to be -.520, .893 and .283, respectively. Based on the deviance values we concluded that the means showed a normal distribution.

Reliability Results Belonging to the EAS, EBSS, EOSS and EESS

As shown in Table 1, the Cronbach' alpha and reliability of the scales in general were found to be α=.94, α=.91, .82 and .94, respectively and the Spearman Brown coefficients were found to be .85, .83, .80 and .85, respectively. The internal reliability coefficients for the factors of the scale were found to be over .77

Table 1. Cronbach's alpha and split-half reliability of the EAS, EBSS, EOSS and EESS and their factors

Scale	Cronbach's Alpha	Spearman Brown Coefficients
EAS	.94	.85
EBSS	.91	.83
Factor 1	.84	.77
Factor 2	.88	.81
EOSS	.82	.80
Factor 1	.82	.80
EESS	.94	.85
Factor 1	.92	.91
Factor 2	.90	.88

As shown in Table 2, there is a high and positive correlation between the students' scores from the EAS and sub scales (r=.844, .605 and .916; p<.001, respectively). Moderate, positive and significant correlation was found between the EBSS and EOSS, EESS (r=.246, .711; p<.001) and between EOSS and EESS (r=.388; p<.001). Hence, it can be claimed that there is a positive consistency between the sub-scales. In light of these findings, it is concluded that the EAS we developed can be confidently used to determine the environmental attitudes of the secondary school, high school and undergraduate university students.

Table 2. Correlation between the environmental attitude scores and their subscales

Parameters		EBSS	EOSS	EESS
EAS	Pearson Correlation (r)	.844(*)	.605(*)	.916(*)
	Sig. (2-tailed)	.000	.000	.000
	N	1320	1320	1320
EBSS	Pearson Correlation (r)	-	.246(*)	.711(*)
	Sig. (2-tailed)	-	.000	.000
	N	-	1423	1445
EOSS	Pearson Correlation (r)	-	-	.388(*)
	Sig. (2-tailed)	-	-	.000
	N	-	-	1382

* Correlation is significant at p<.001

Validity (Factor Analysis) Results Concerning the Environmental Behavior Sub Scale

In order to test the compliance of the data with the factor analysis a Kaiser-Meyer-Olkin (KMO) coefficient and Bartlett Sphericity test were examined. A high value KMO coefficient (KMO coefficient=.924) and Bartlett test' being significant (p<.001) showed the compliance of the data with the factor analysis (Büyüköztürk, 2005). Hence, it is possible to claim that the KMO coefficient is an acceptable value (Table 3).

Table 3. Kaiser-Meyer-Olkin (KMO) coefficient of the environmental behavior sub scale and Bartlett Sphericity test results

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.924
Bartlett's Test of Sphericity	Approx. Chi-Square	9644.688
	df	78
	Sig.	.000

When Table 4 is examined, results show that the 13 items in the scale are subsumed under two factors with an eigenvalue above 1. The first factor explains 31.8% of the variance on its own, and the second factor explains 26.1% of the variance, together they explain 57.9% of the total variance. The common variance of the two factors defined in relation to the items ranges from .446 to .663. The findings in Table 4 show that the first six items in the scale constitute the first factor and items between 7 and 13 comprise the second factor.

Table 4. Factor analysis results concerning the environmental behavior sub scale

Items	Communalities	Factor-1 Component Matrix	Rotated Component Matrix	
			Factor 1	Factor 2
1	.504	.673	.608	
2	.556	.599	.727	
3	.524	.652	.663	
4	.636	. 749	.694	
5	.593	.652	.735	
6	.567	.583	.741	
7	.623	.728		.751
8	.663	.726		.792
9	.658	.740		.779
10	.596	.709		.737
11	.607	.768		.668
12	.446	.632		.620
13	.549	.691		.700
	Explained variance	Total: 57.9%	Factor 1: 31.8%	Factor 2: 26.1%

The loading values of the items in the first factor ranges between .608 and .741. This range is between .620 and .792 for the items of the second factor (Table 4).

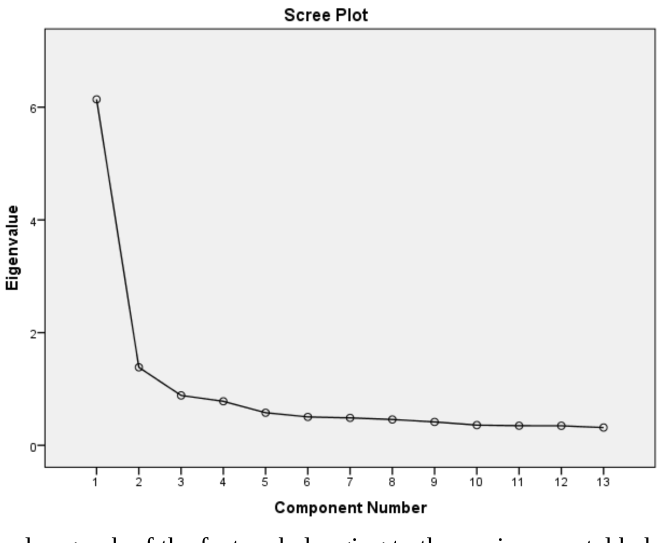

Figure 1. Eigenvalue graph of the factors belonging to the environmental behavior sub scale

Figure 1 shows that there is a high momentum fall after the first factor in the scree plot according to eigenvalues. This finding indicates that the scale may have a general factor. On the other hand, a relatively lower fall observed after the second factor indicates that the number of the significant factors is two. The contributions of the other subsequent factors to the variance are close to each other. The first factor loadings of all the items of the scale are .608 or above. These results indicate that the scale has a general factor. Hence, besides using the scale with two factors, it is suitable to use it with one factor.

Validity (Factor Analysis) Results Concerning the Environmental Opinion Sub Scale

In order to test the compliance of the data with the factor analysis a Kaiser-Meyer-Olkin (KMO) coefficient and Bartlett Test of Sphericity were utilized. A high value KMO coefficient (KMO coefficient=.905) and Bartlett test was significant (p<.001) showing the compliance of the data with the factor analysis indicates that the KMO coefficient was an acceptable value (Table 5).

Table 5. Kaiser-Meyer-Olkin (KMO) coefficient of the environmental opinion sub scale and Bartlett Sphericity Test results

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.905
Bartlett's Test of Sphericity	Approx. Chi-Square	3782.886
	df	55
	Sig.	.000

Table 6 shows that the 11 items in the scale are subsumed under one factor with an eigenvalue above 1. The factor explains 37% of the variance on its own, and explains 37% of the total variance. The common variance of the factor defined in relation to the items ranges from .232 to .501. The loading values of the items in the factor ranges between .481 and .708.

Table 6. Factor analysis results concerning the environmental opinion sub scale

Items	Communalities	Factor-1 Component Matrix
1	.401	.634
2	.397	.630
3	.232	.481
4	.238	.488
5	.320	.566
6	.312	.559
7	.425	.652
8	.501	.708
9	.455	.674
10	.404	.636
11	.382	.618
	Explained variance Total: 37%	Factor 1: 37%

Figure 2 indicates a high momentum fall after the first factor in the line graph plotted according to eigenvalues. This finding indicates that the scale may have a general factor.

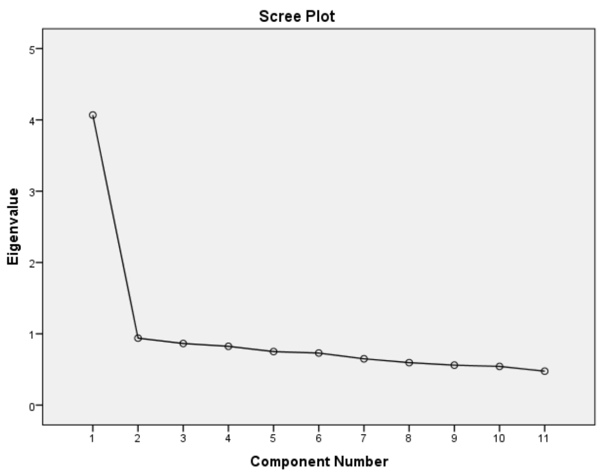

Figure 2. Eigenvalue graph of the factors belonging to the environmental opinion sub scale

Validity (Factor Analysis) Results Concerning the Environmental Emotion Sub Scale

In order to test the compliance of the data with the factor analysis a Kaiser-Meyer-Olkin (KMO) coefficient and Bartlett Test of Sphericity were examined. A high value KMO coefficient (.961) and Bartlett test' being significant ($p<.001$) indicates that the compliance of the data with the factor analysis shows that the KMO coefficient is an acceptable value (Table 7).

Table 7. Kaiser-Meyer-Olkin (KMO) coefficient of the environmental emotion sub scale and Bartlett Test of Sphericity results

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.961
Bartlett's Test of Sphericity	Approx. Chi-Square	14583.233
	df	120
	Sig.	.000

Table 8 findings indicate that the 16 items in the scale are subsumed under two factors with an eigenvalue above 1. The first factor explains 31.2% of the variance on its own and the second factor explains 30.1% of the variance. Together they explain 61.3% of the total variance. The common variance of the two factors defined in relation to the items ranges from .544 to .692.

Table 8. Factor analysis results concerning the environmental emotion sub scale

Items	Communalities	Factor-1 Component Matrix	Rotated Component Matrix	
			Factor 1	Factor 2
1	.632	.774	.679	
2	.544	.666	.698	
3	.631	.775	.677	
4	.655	.693	.788	
5	.661	.756	.750	
6	.651	.723	.767	
7	.692	.802	.729	
8	.652	.789	.686	
9	.645	.706		.767
10	.691	.769		.762
11	.590	.751		.641
12	.564	.705		.677
13	.556	.724		.634
14	.559	.707		.667
15	.544	.632		.713
16	.549	.664		.698
	Explained variance	Total: 61.3%	Factor 1: 31.2%	Factor 2: 30.1%

The first eight items in the scale constitute the first factor and last eight items make up the second factor. The loading values of the items in the first factor ranges between .677 and .788, the range is between .634 and .767 for the items of the second factor (Table 8).

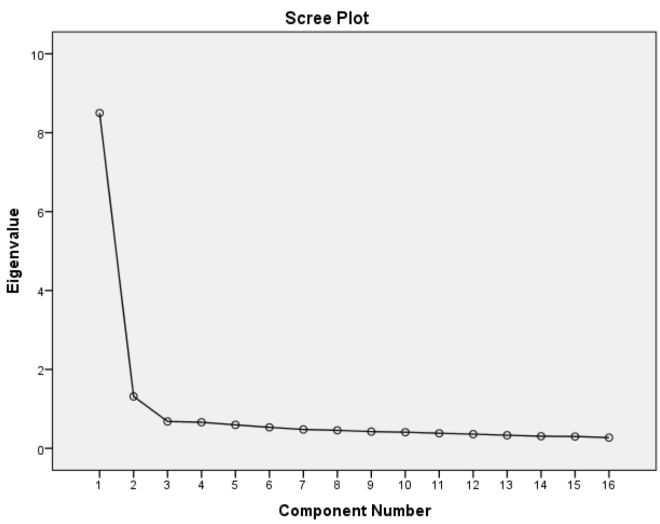

Figure 3. Eigenvalue graph of the factors belonging to the environmental emotion sub scale

The scree plot in Figure 3 shows a high momentum fall after the first factor in the line graph plotted according to eigenvalues. This finding indicates that the scale may have a general factor. On the other hand, a relatively lower fall observed after the second factor indicates that the number of the significant factors is two. The contributions of the other subsequent factors to the variance are close to each other and thus are not considered. First factor loadings of all the items of the scale are .677 or above. These results further indicate that the scale has a general factor. Besides using the scale with two factors, it is suitable to use it with one factor.

Results and Discussion

The aim of this work was to develop a valid and reliable "Environmental Attitude Scale" to determine the attitudes of secondary school, high school and undergraduate university students towards the natural environment. Within the context of the validity of the scale the content and construct validity were tested. By reviewing the relevant literature, in addition to the dimensions of behavior and opinion, 20 items were included under the affective sub-dimension of the scale in the item pool. To establish the content and face validity, the items were submitted to the scrutiny of three experts in environmental education. In line with the expert opinions and results of piloting and actual application, 7 of the 47 items in the item pool were discarded and thus a 40-item scale was obtained.

In order to analyze the factor structure of the data collected through the scale, an exploratory factor analysis (EFA) was conducted. The findings show that the data are suitable for factor analysis. These factors of the scale indicated a three-factor structure complying with the three dimensions of the attitude towards environment; namely, opinion, behavior and emotion reported in the attitude literature. Therefore, the scale is composed of three sub scales "Environmental Behaviour Sub Scale (EBSS)", "Environmental Opinion Sub Scale (EOSS)" and "Environmental Emotion Sub Scale (EESS)".

The Cronbach's alpha and Spearman Brown coefficients show that the instrument has a high reliability. The Cronbach alpha reliability coefficient for the whole scale was found to be α=.94, and reliability coefficient of the first subscale was found to be α=.91, second subscale α=.82 and third subscale α=.94 and the Spearman Brown coefficients were found to be .85, .83, .80 and .85, respectively. The findings show that the EBSS and EESS consist of two factors each and the EOSS consists of one factor. The EBSS has 13 5-point Likert-type items, the EOSS has 11 and EESS has 16 items.

There was a high positive correlation between the scores obtained from the EAS and sub scales (r=.844, .605 and .916; $p<.001$, respectively). It was found that EBSS items are subsumed under two factors with an eigenvalue above 1. The first factor explains 31.8% of the total variance and the second factor explains 26.1% of the total variance. Together they explain 57.9% of the total variance. In a line graph, after the first factor, a decrease with high momentum was observed indicating that the scale may have a general factor. After the second factor, a decrease with relatively lower momentum was observed indicating that the number of the factors is two.

It was found that EOSS items are subsumed under one factor with an eigenvalue above 1. This factor explains 37% of the total variance. In the line graph, after the first factor, a decrease with high momentum was observed indicating that the scale has a general factor. It was found that EESS items are subsumed under two factors with eigenvalue above 1, first factor explains 31.2% of the total variance and the second factor explains 30.1% of the total variance and together explain 61.3% of the total variance. In the line graph, after the first factor, a decrease with high momentum was observed indicating that the scale may have a general factor. After the second factor, a decrease with relatively lower momentum was observed indicating that the number of the factors is two.

In the behavior dimension of the Environmental Attitude Scale (EAS), statements such *as I want to voluntarily participate in any activity organized related to the environment at school; while purchasing a product, I prefer a recyclable one; I read books about environmental issues apart from textbooks*; in the opinion dimension of the scale, statements such as *The environment can clean itself, human wastes are not a problem; while going out of a room, turning off the light does not lead to great amount of energy saving; in the world, there is so much water that humans can never use all of it;* and in the affective dimension, statements such as *environmental pollution caused by wars angers me; natural disasters such as the tsunami is extremely worrying; it gives me more pleasure to go for an outdoor activity instead of shopping* were included.

The reliability and validity results of the study show that Environmental Attitude Scale can be used responsibly to measure the environmental attitudes of the different level students. Because the EAS applies to different countries (Turkey, USA, and Finland) and across differing upper grade levels, it provides a good contribution to the field of Environmental Education by being a tool that can measure attitude changes through time and/or through differing types of studies about the natural environment that include attitude measures. Application of the scale to determine the environmental attitudes with respondents from three different countries are thought to contribute to the environmental education research by establishing an attitude scale that is applicable globally. The developed Environmental Attitude Scale is important as it includes the sub-dimensions of behavior, opinion and emotion. In further research, these dimensions can be used individually.

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Appendix: Environmental Attitude Scale

	a - Environmental behavior sub-scale	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
1	I watch environmental programs that are broadcast on TV and radio.					
2	I read about environmental issues in daily newspapers.					
3	I watch environmental documentaries.					
4	I read books about environmental issues apart from textbooks.					
5	I read popular environmental journals.					
6	I read scientific articles about the environment.					
7	I warn a person who is damaging the environment without hesitation.					
8	I want to voluntarily participate in any activity organized related to the natural environment at school.					
9	My friends see me as a person who is sensitive to the environment.					
10	If necessary, I am willing to work for a livable environment for a long time with low pay.					
11	I share my knowledge about the environment with my friends.					
12	While purchasing a product, I prefer to buy recyclable ones.					
13	Even if it is more expensive, I prefer to buy goods that are not harmful to the environment.					
	b - Environmental opinion sub-scale	**Strongly disagree**	**Disagree**	**Partially agree**	**Agree**	**Strongly agree**
1	I think that endangered species are exaggerated, that there are many species in nature; So, it is not important for a few of them to be extinct.					
2	It is better to spend money on the construction of high-quality roads rather than on historical sites.					
3	There is no erosion in our country any more.					
4	Pesticides used in agriculture are useful for environment.					
5	There is nothing wrong to sell areas that have lost their natural characteristics to bring money to our country.					
6	Construction of hotels for tourism in national parks and forests should be allowed.					
7	For housing, wetlands should be drained so houses can be built there.					
8	Since the environment can clean itself, human wastes are not a problem.					
9	The Ozone layer has been thinned so there is no danger for our country.					
10	While going out of a room, turning off the light does not save much energy					
11	In the world, there is so much water that humans can never use all of it.					

	c - Environmental emotion sub-scale	**Strongly disagree**	**Disagree**	**Partially agree**	**Agree**	**Strongly agree**
1	I am angry with people who cause environmental pollution.					
2	Natural disasters such as a tsunami are extremely worrying.					
3	I worry about the global environmental issues.					
4	I get angry if anybody damages any live plants or animals.					
5	Environmental pollution caused by wars angers me.					
6	If I don't warn the people who damage habitat for animals, I would regret it.					
7	I feel anxious because of the decrease of the forests.					
8	I feel guilty when I do harm to the environment.					
9	Hiking in natural areas gives me peace of mind.					
10	I get excited when I participate in any activity in nature.					
11	Generally, I would be proud of myself because of my sensitivity to the environment.					

12	I would be happy doing nature based sports such as hiking.					
13	I am curious of the changes in nature.					
14	I would be satisfied if we have more environmental lessons in school.					
15	It gives me more pleasure to go for an outdoor activity instead of shopping.					
16	Being alone in nature relaxes me.					

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Defining Friction Force: A Proposed Solution to a Textbook Problem

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Abstract

Scientific concepts are the building blocks of scientific thought and science communication. Therefore, to achieve scientific literacy it is necessary to construct and define the concepts accurately. In this study, the concept of friction force, which is frequently encountered in science textbooks, is discussed. The explanations of the concept in science textbooks have been found to be inadequate in effectively explaining several situations. To address this issue, this study aimed to examine the concept of friction force in the textbooks and to propose a more comprehensive definition. The study was conducted using the document analysis method. A total of 26 resource books (11 university physics textbooks, 4 science-term glossaries, 2 secondary school physics textbooks, 6 middle school science textbooks, and 3 popular science textbooks) were analyzed in the study. Several inconsistencies in the explanations for the concept of friction force were found. Based on the analysis, a more comprehensive definition was proposed to fully and consistently explain the effects and the direction of friction force.

Introduction

Achieving the goal of "science for all" requires us to educate scientifically literate students. One of the facets of scientific literacy is to understand the concepts and phenomena related to science (Roberts, 2007). In other words, students' ability to learn science as a culture effectively is related to the quality of the conceptual teaching applied in science classes (Akgün, Gönen & Yılmaz, 2005; Yağbasan & Gülçiçek, 2003). Despite the importance of "building block" concepts in science teaching and the many contemporary teaching approaches employed in science classes to teach these concepts, it has been revealed that students still have misconceptions in various subject domains (Atasoy & Akdeniz, 2007; Aydoğan, Güneş & Gülçiçek, 2003; Coştu, Ayas & Ünal, 2007; Küçük, 2005; Tekkaya & Yilmaz, 2000). This is still a pressing issue in science education; misconceptions may negatively affect learners' achievements and reduce their success in science (Driver & Easley, 1978; Kumandaş, Ateşka, & Lane, 2018). However, several studies have emphasized the difficulty of changing the misconceptions that students have (Bilgin & Geban, 2001; Gunstone, White & Fensham, 1988). For this reason, a variety of methods and strategies have been developed so that students can adequately construct science concepts when they are first introduced (Atasoy, Küçük & Akdeniz, 2011; Kinchin, 2000; Novak, & Musonda, 1991).

Concepts need to be defined correctly—before explaining the methods and strategies used to construct the concepts. In this way, the formation of misconceptions can be prevented. A definition explains something using the basic elements and features of the known related concepts. In terms of defining a concept correctly, it is necessary to understand the nature of the basic elements and properties of that concept. During this process, lacking the ability to distinguish the characteristics of a concept, making inadequate associations, making over– or under-generalizations, or misidentifying the concept could cause students to have alternative conceptualizations (Garnett & Treagust, 1992, Tery, Jones & Hurford, 1985, Yağbasan & Gülçiçek, 2003).

Other possible reasons for misconceptions include "lack of information," "no experiments for concretization," "teachers' presentation styles," "previous experiences and thoughts of students," "inadequate associations," and "textbooks" (Coştu et al., 2007). Textbooks are listed among these factors because they sometimes contain information that becomes a source of alternative conceptions or misconceptions. It is also stated that the inscriptions used for narrative purposes in textbooks can cause misconceptions (Sung, Shen, Stanger-Hall, Wiegert, Li, Brown, & Robertson, 2015). Despite their flaws, textbooks will always have an important place in the planning, implementation, evaluation, and development of education and training activities (Güzel, Oral, & Yıldırım, 2009). They are a basic medium that inform and explain the subjects in the curriculum in a planned and regular way, and guide students in the direction of the course as a source of information (Ünsal & Güneş, 2003). Accurate identification of concepts in the textbooks helps teachers, program writers, textbook authors, and teachers in guiding students in their conceptual learning. Since textbooks are one of the most used resources by students, they should be prepared and examined meticulously. For these reasons, it is especially necessary to examine and renew those textbooks that are thought to be a source of misconceptions for science learners (Çapa, 2000).

Students' Conceptual Understandings and Misconceptions of Friction Force

The abstract concepts in science make it one of the most challenging subject areas for students to comprehend (Günbatar & Sarı, 2005). Most commonly these concepts are taught as isolated facts (Linn, 2006). In physics, force and friction are the main concepts of classical mechanics (Driver et al., 1994), and—it has been repeatedly found—a common source of student misconceptions (McDermott & Redish, 1999). For example, Aristoteles asserted that there is a need for a force to hold a subject in motion (Atasoy et al., 2011). In the 14th century William realized and proved that once a force is present there is no need for a constant force to maintain it (Cushing, 1998). Despite this conceptual change, multiple researchers have found that students had an Aristotelian understanding of this concept (Atasoy et al. 2011; Driver et al., 1994; Jimoyiannis & Komis, 2003; Palmer, & Flanagan, 1997). Identifying their misconceptions can help teachers understand how students are coming to this outdated conclusion. Without a firm base understanding of previous material (particularly forces and energy), students often struggle with defining friction force in relation to force in general. Studies have shown that even some preservice teachers do not see friction as a type of force (Trumper & Gorsky, 1996; 1997; Yıldız & Büyükkasap, 2006). If friction is not identified as a force, students could develop an intuitive image that constant movement requires a constant force (Driver, Guesne, & Tiberghien, 1985), thus arriving at the Aristotelian understanding.

Studies on students' conceptual structures have revealed several of these kinds of differences in their understanding of friction force. It is important to identify these differences in order to identify the factors leading to the resulting misconceptions and prevent them. For instance, in a recent study Tavukçuoğlu (2018) investigated the cognitive structures that high school students use to understand about friction force. The results indicated that the students mostly expressed ideas on "the variables affecting friction force"; they had limited knowledge of the higher order cognitive skills connected with the subject. Furthermore, they had limited conceptualizations of the direction of friction force. Many students explained friction force simply as the force that has an opposite direction to motion. These issues affected their ability to define friction force correctly.

Researchers have found that most students define friction force as follows: a force that makes movement difficult and has an opposite direction effect on an objects' movement direction (Tavukçuoğlu, 2018). Although the students in one study knew that friction force reduces speed, several had difficulties guessing how an object would move after the friction force was removed from the environment (Nuhoğlu, 2008). As a result of these imperfect definitions and lack of understanding, students hold common misconceptions about the concept of friction force (Tavukçuoğlu, 2018). As researchers identify specific misconceptions that occur in different populations, this information can be used to narrow the definition of friction force and preemptively avoid problem areas in subject instruction and textbook creation.

One common misconception is that friction force is only related to motion and can only be seen when motion is present (Dixon, 2005; Trumper & Gorsky, 1997). Students often confuse reaction force with friction force and think that the two are the same (Nuhoğlu, 2008). Studies indicate that students also make mistakes when determining the direction of friction force; for example, middle school students have a misconception that if the friction force is applied towards the direction of the movement, it increases an object's speed (Tavukçuoğlu, 2018; Prasitpong & Chitaree, 2009). Similarly, Chee (1996) noted that some students mistakenly believe that during the motion of walking or riding a bicycle friction applies a backwards force to the feet and rear wheel. Moreover, students think that the friction force is related to the surface area of the other object (Hançer, 2007). Finally, students believe that friction is a result of the roughness of the surface alone (Genç, 2008; Hapkiewicz, 1992), and that there is not friction on smooth surfaces (Genç, 2008; Akbulut, 2018).

One of the main aims of education and training is to allow for the proper initial construction of concepts rather than solely correcting students' misconceptions. Textbooks are one of the main sources that influence this concept formation. Many of the current science textbooks have been studied in the context of several subject areas to determine their effects on students' conceptualizations (e.g. Staver, & Lumpe, 1993; Leite, 1999; Sung et al., 2015). Nonetheless, little is known about what factors affect students' conceptualizations of the friction force concept. Therefore, the purpose of this study was to examine the way the concept of friction force is presented in textbooks and to provide an explanatory definition of the friction force concept.

Table 1. Examined textbooks and detailed information

Title	**Author(s)**	**Level**	**Date**	**Publisher**
Physics in the modern world	Jerry B. Marion	University	1989	Technical University Press
Essentials of Physics	Sidney Borowitz, Arthur Beiser	University	1982	Bursa University Printing House
Physics for Scientists and Engineers, Cilt: 1	Raymond A. Serway, Robert J. Beichner	University	2003	Palme Publishing
Physics for Scientists and Engineers	Paul M. Fishbane, Stephen Gasiorowicz, Stephen T. Thornton	University	2003	Arkadas Publisher
Scientific Principles of General Physics and Technology	Metin Orbay, Feda Öner	University	2006	Pegem Akademi Publishing
Modern University Physics	James Austin Richards, Francis Weston Sears, M. Russell Wehr, Mark W. Zemansky	University	1989	Çağlayan Bookstore
General Physics I: Newtonian Force and Motion Theory	Mehmet Fatih Taşar, Metin Orbay	University	2008	Pegem Akademi Publishing
Principles of Physics	Frederick J. Bueche, David. A. Jerde	University	2003	Palme Publishing
Sear’s and Zemansky's University Physics with Modern Physics	Hugh D. Young, Roger A. Freedman	University	2010	Pearson Educatıon Publishing
Physics for Scientists & Engineers	Douglas C. Giancoli	University	2009	Akademi Publishing
Physics	Frederick J. Keller, W. Edward Gettys, Malcolm J. Skove	University	2005	Literatür
Physics Terms Dictionary	M. Ali Avundukluoğlu, Şeref Turhan		2007	Ötüken Publication
Physics Terms Dictionary	Şakir Aydoğan		2007	Aktif Publisher
Science and Art Terms Dictionary	Commission		2018	Turkish Language Foundation
Turkish Science Terms Dictionary	Commission		2018	Turkey Academy of Sciences
The Visual Dictionary of Physics	Jack Challoner	Popular science	2008	TÜBİTAK Publications
Illustrated Dictionary of Physics	Chris Oxlade, Corinne Stockley, Jane Wertheim	Popular science	2010	TÜBİTAK Publications
What’s Science All About?	Alex Frith, Hazel Maskell, Lisa Jane Gillespie, Kate Davies	Popular science	2012	TÜBİTAK Publications
Physics	Canan Sever, Demet Türeci, Nadire Artar, Orhan Dağ	High school-9th grade	2017	Ministry of National Education
Physics	Ali Seyfi Koyuncuoğlu	High school - 11th grade	2017	İpekyolu
Science and Technology	Commission	Middle school-7th grade	2012	Ministry of National Education
Science	Emine Tuncel	Middle school-7th grade	2016-2017	Mevsim Publishing
Science	Gülçin Gündüz	Middle school-7th grade	2016-2017	Sonuç Publications
Science	Seval Akter, Hatice Betül Arslan, Meltem Şimşek	Middle school-5th grade	2017-2018	Ministry of National Education
Science	Hülya Özdoğan	Middle school-5th grade	2015-2016	Semih Ofset
Science	Commission	Middle school-5th grade	2016	Ministry of National Education

Methods

In this study, the document analysis method was used to investigate the definitions of friction force found in science education books (Merriam, 2009). Resource books and textbooks used in Turkey at the university, secondary, and middle school levels were considered as data sources. We analyzed a sample of 26 books via convenience sampling based on the recommendations of experts in physics education. The sections where friction force was mentioned in the books constitute the data analysis unit of the study. The data obtained in the study were analyzed by the content analysis method. Content analysis allows in-depth analysis of the data to reveal previously unfamiliar themes and patterns (Miles, & Huberman, 1994). A total of 26 resource books—11 university physics textbooks, 4 science-terms glossaries, 2 secondary school physics textbooks, 6 middle school science textbooks, and 3 popular science textbooks—were examined in the study. Detailed information on the books examined is presented in Table 1.

Findings

Within the scope of the study, explanations about friction force were pulled from the textbooks that comprise the primary data source. These explanations were looked at individually and analyzed regarding their definition of the concept of friction force, the situations where friction force is effective, and the direction of friction force. How friction force is defined in the source books is examined first. We found two conceptual definitions of friction force: "motion" and "slide." Slide and motion concepts are scientifically defined as follows (Ayverdi, 2008):

> **Sliding**: "(Something or someone) Moving over something wet, lacquer, or slippery without being subject to the floor"
>
> **Movement**: "Move, or move the position, position or status of an object or part of an object."

Table 2. Example definitions for the concept of friction force in source books

Category	Book	Definition
Motion	Physics for Scientists and Engineers, Volume: 1, Palme Publishing	If an object is moving on a rough surface or in a viscous environment such as air or water, there is resistance to movement due to the interaction with the environment. We call such resistance a friction force (Serway & Beichner, 2003, p. 112)
	Physics Terms Dictionary, Ötüken Publication	The force of two objects' contact surfaces that intersect each other and the forces of attraction between the molecules cause the motion to slow down, thus counteracting the direction of movement and equal to the opposite sign of the coefficient of friction and the product of normal force (Avundukoğlu &Turhan, 2007, p. 352-353)
	The Visual Dictionary of Physics, TÜBİTAK Publications	Friction is a force that slows or prevents movement (Challoner, 2008, p. 14)
	Physics, Highschool-9th grade, Ministry of National Education	The contact force between the surfaces is called friction force against movement or forcing. (Sever, Türeci, Artar & Orhan, 2017, p. 150)
	Science, Middle school-7th grade, Mevsim Publishing	The resistance of the two materials in contact with each other is called the friction force. (Tuncel, 2016, p. 96)
	Science, Middle school-5th grade, Ministry of National Education	It is called friction force which is formed between the surface that touches the object and makes the motion of an object difficult (Akter, Arslan & Şimşek, 2017, p. 93)
Slide	Physics for Scientists and Engineers, Arkadaş Publisher	Friction, a well-known concept, is a contact force that prevents sliding. (Fishbane, Gasiorowicz & Thornton, 2003, p. 119)
	Turkish Science Terms Dictionary	Resistive force that acts on an object and prevents or slows it to slide relative to the second object or surface where the object is the contact (Commission, 2018).

Table 3. Example situations where friction force is effective

Books	Explanations
Physics for Scientists and Engineers, Cilt: 1, Palme Publishing	Friction forces are very important in our daily life. This force is necessary for us to walk, to run, to stop, to move and stop the cars (Serway & Beichner, 2003, p. 112).
Physics for Scientists and Engineers, Arkadas Publisher	With this force people can walk, cars can move on the roads, and even nails and screws stay in place thanks to this force. Reduction of friction on moving machine parts is possible by lubricating the friction surfaces. In the automobile, 20 percent of the motor's power is spent to defeat internal friction, and wear begins where the friction is (Fishbane, Gasiorowicz & Thornton, 2003, p. 119).
Sear's and Zemansky's University Physics with Modern Physics, Pearson Education Publishing	The oil used in car engines reduces rubbing between the engine parts. If there is no friction between the car wheels and the road, we can neither drive nor control the car. Without the friction, the nails did not stand in place, the lightbulbs could easily get out of their socket (Young & Freedman, 2010, p. 149)
Science and Technology, Middle school-7th grade, Ministry of National Education	So, does the friction force always prevent movement? The athlete seen in the adjacent photo uses an acceleration block to start the run faster. When we walk or run, there is a friction force between our feet and the ground. This frictional force that is created makes it easy for us to move forward (Commission, 2012, p. 94)
Science, Middle school-5th grade, Ministry of National Education,	In the winter, attaching chains to the tires of cars will increase the friction force and prevent the car from sliding. The wheels attached to the bottom of the suitcase to move a heavy suitcase easily reduce the friction. So the object is moved more easily (Commission, 2017, p. 98)

Example definitions describing are given in Table 2, separated into "motion" and "slide" categories. Based on our analysis, we found that a total of 17 books used *motion* and 9 books used *slide*. While each of the source books define friction force, they also discuss its effects in practice and ways of reducing friction in daily life. Table 3 provides examples of the given situations. One contradiction or inconsistency is noteworthy when examining the above explanations of cases where friction force is effective. Friction force is described as an inhibiting force, and it is also considered necessary to ensure movement.

Table 4. Directions of the friction force in the source books

Books	Explanations
Modern Universty Physics, Çağlayan Bookstore	When an object slides on another object, it applies a friction force parallel to the sliding surface. This force is opposite to the relative movement of objects relative to each other. (Richards, Sears, Wehr & Zemansky, 1989, p. 33)
Physics for Scientists and Engineers, Cilt: 1, Palme Publishing	The results of the experimental observations can be summarized by the following friction laws: 1. The static frictional force between two opposing surfaces is opposite to the applied force 2. The kinetic frictional force acting on a moving object always arises in the opposite direction of the objects' movement (Serway & Beichner, 2003, p. 113)
Physics for Scientists and Engineers, Arkadas Publisher	Static friction affects the strength applied to the sand opposite the surface component. Kinetic friction is effective on the opposite direction of the moving objects' speed and one or more contact points (Fishbane, Gasiorowicz & Thornton, 2003, p. 120)
Science, Middle school-5th grade, Ministry of National Education	The direction of movement of the object is reversed (Akter, Arslan & Şimşek, 2017, p. 93)
Science, Middle school-5th grade, Ministry of National Education	Friction force occurs in the opposite direction, which provides movement of the object between surfaces touching each other (Commission, 2016, p. 86)
Science, Middle school-7th grade, Mevsim Publishing	The direction of the frictional force is opposite to the direction of movement (Tuncel, 2016, p. 97)
Science, Middle school-7th grade, Sonuç Publications	Friction force is always opposite to objects' movement (Gündüz, 2016, p. 83)

However, in some sources friction force is defined by the concept of "motion", but it is also revealed by being associated with the concept of "sliding". For example, it is stated that while the friction force is given as an obstructive force against movement in the 5th grade science course textbook, the friction force prevents the sliding of the cars. In this case, it is understood that there is no separation between the concepts of "motion" and "sliding" in textbooks. To define the effects of any force it is important to explain the force's direction. Explanations found in the data for determining the direction of friction force are given in Table 4

In the data sources, it is often incorrectly stated that friction force acts in the opposite direction of the motion of an object. However, some university textbooks state that friction force against static objects will affect the object in a direction opposite to the horizontal force applied. Many of the textbooks use visual instructional materials that indicate the direction of forces. Examples of diagrams related to friction force in the textbooks analyzed are given below. The direction of motion of both the objects in the figures and the forces affecting these objects are shown with the help of vector expressions.

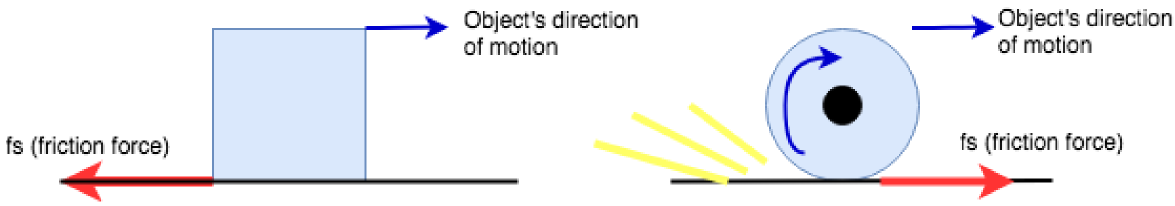

Figure 1. Figures based on the figures in Sever, Türeci, Atar, & Dağ, 2007

The rectangular body in Figure 1 (i.e. figures recreated by the authors based on the figures in Sever, Türeci, Artar, & Dağ, 2017, p. 153) is affected by friction in the opposite direction of its movement, while the circular disc is affected in the direction of movement. Similarly, in a figure in Fishbane, Gasiorowicz & Thornton (2003, p.124), the friction force acting on the tires of the car in motion is shown in the same direction as the car. As can be seen in Figure 1, the circular disk drive moves clockwise at the point where the force is in contact with the ground. Thus, in Figures 1 frictional force in circular discs appears to move in the direction of object's movement.

Diagrams in Akter, Arslan and Şimşek (2017, p.95) and Challoner (2008, p.15), however, show a different picture. Each diagram indicates visually that the friction force acting on spherical moving bodies acts in reverse to the objects' motion. In figures that were used in these primary education and popular science books, the friction force direction is incorrectly assigned. This confirms the findings in Table 4, indicating that some (or most) of the available textbooks suggest that the direction of the friction force is determined by the object's movement. Determining the causes of these mistakes will allow for clearer instruction for students and pre-service teachers on how to make direction determinations.

Discussion, Suggestions, and Conclusion

In this study, the authors examined definitions of "friction force" in textbooks. Several issues appear. First, all the definitions in middle school science textbooks and secondary school physics textbooks explain friction force in relation to the concept of *motion*. Mostly, friction force is expressed as a "force to inhibit movement." When inhibition is emphasized, friction is defined as an obstructive force, even though in some cases it is necessary to *enable* movement. Thus, friction force is simultaneously explained as both a movement inhibitor and a driving force, despite the fact that these two conditions are naturally incompatible. One explanation for this conceptualization in the textbooks might be due to the colloquial use of the term friction (Shen & Linn, 2011), which might sometimes indicate an "influential factor" opposite to movement (Sung et al., 2015). A clear definition should be able to explain naturally occurring events and to display internal consistency. For this reason, we conclude that referring to the concept of "motion" might not be a suitable choice when describing friction force.

Second, friction force is defined by using the concept of "sliding" in some university textbooks and science glossaries. Similar conflicts can be seen in the literature; there are inconsistencies presenting concepts even within the same textbook. For example, Flodin (2007) investigated how a biology textbook dealt with the gene concept. The results showed that the concept was used inconsistently across the book in several different ways. For example, it is sometimes described as a trait, an information-structure, an actor and later referred to as a regulator and a maker. Similarly, in this study the texts explained friction force using several different "daily life" cases related to sliding in addition to motion. For example, we can move across surfaces by walking or rolling where the friction is strong because the sliding does not occur between the surfaces. In the absence of friction, objects can move by sliding. In cases where friction is present, we can walk, so we can move because the sliding situation does not happen. In this context, it is understood that the friction force is not a force to inhibit movement but a force to inhibit sliding.

One problem factor in using motion to explain friction is the concept of rolling motion. Rolling bodies move forward due to friction between their own surface and the ground. The horizontal force acting on the contact point causes rolling motion when it is less than the maximum friction force generated between the object and the ground. The friction force between the object and the contacted surface will cause the object to slide if it is less than the horizontal force acting on the object; this distinction is the key reason motion and sliding must be differentiated in the definition.

When explaining friction force, the textbooks studied used the concept of "motion" to define or explain friction force, while the idea of "sliding" was used to describe situations where friction is encountered in everyday life. This misrecognition of difference indicates that the concept of "motion" alone is an over-generalization, not suitable for describing the friction phenomenon. When the definitions of each term are examined, it is evident that the concept of "motion" expresses a more general condition than the concept of "sliding." In other words, movement can be achieved without sliding, though sliding cannot occur without motion. Researchers argue that textbooks should avoid using simplifications and vague statements when defining scientific concepts to avoid these issues (Sanger & Greenbowe, 1999). Therefore, one potential resolution of this conflicting conceptualization is to define and explain friction force in relation to the concept of "sliding" instead of "motion."

Third, the literature shows that students have misconceptions about friction force across different subject contexts (Sağlam, Kanadlı, & Uşak, 2012). Friction is often understood at the macroscopic level and as a result students do not develop cognitive structures related to microscopic phenomena (Tavukçuoğlu, 2018). In a similar study, Kurnaz and Ekşi also noted that most students think of friction at the macroscopic level and have difficulties conceptualizing it at the microscopic level (Kurnaz & Ekşi, 2015). Excessive generalization of friction force in relation to motion is thought to factor into such conceptualizations. Concepts need to be defined specifically and correctly so that students can conceptualize at different levels of context and explain facts and events accurately across subject areas (Sanger & Greenbowe, 1999).

For a concept to be correctly defined in this way, its nature must be understood. For this reason, when describing the concept of friction force, it is necessary to know how friction occurs. The formation of friction is expressed in textbooks as follows (Giancoli, 2009, p. 113):

> It is thought that the atoms on the surface of a surface can come very close to the atoms on the other surface and the attractive electrical forces between the atoms can "bond" as if a thin source exists between the two surfaces.

When the formation of friction is examined, it is seen that friction is a contact force and that contact surfaces have a nature that interferes with certain interactions with each other. If friction force is considered only in this context, it can be explained accurately and consistently while avoiding the other issues that arise with more problematic explanations. The definition proposed by this paper can be summarized as:

> Friction force is a force that prevents sliding.

When we look at the explanations in the textbooks about friction force, there is a noteworthy misconception about its direction. Textbooks state that friction force acts in a direction opposite to motion. This directionality, as expressed in the context of motion, can only be regarded as correct in limited situations, i.e., for objects that move by sliding—when there is no movement, there is still friction force. These kinds of inconsistencies in the data pool mirror a previous study showing that there are inconsistencies in accurately representing science concepts in textbooks, which in return could contribute to student misconceptions in physics (Wong & Chu, 2017).

The example of walking or rolling motion is also problematic because of its complexity and the partial role that friction plays in the process. In visual materials in primary education and popular science books, the friction forces acting on rolling objects are often drawn incorrectly. In the case of walking and rolling, contrary to the case of sliding, the direction of the friction force is in the same as the direction of movement of the object. If the maximum friction force between the ground and the object is not exceeded in rolling and walking situations, sliding does not occur but movement can still be achieved. Note that the movement of the entire system is mentioned here, not movement because of sliding on the contact point. Such movement is affected by the friction at the contact point and other forces acting on the system. Here friction causes objects not to slide, while other forces acting on the system cause the movement. When the direction of the friction force is determined, the motion of the entire system is taken into consideration. Thus, there is a mistake in determining and illustrating the direction of the friction force. One of the main reasons for the emergence of these mistakes is neglecting causal relations (Chiappetta, Sethna, & Fillman, 1991), which are among the primary elements of scientific thought. When the friction force's directional determinations are made, the reasoning is based only on the results, neglecting some of the factors at play. In fact, the direction of the friction force should be determined in terms of the force causing the sliding. During sliding motion, friction force moves in the opposite direction, which forces the object to shift. In the same way, in the walking and rolling situations where there is no sliding motion, the direction of the friction force is opposite to the force which wants to shift the body. In this case, the direction of friction force can be expressed as:

> Frictional force occurs in the opposite direction of the tendency to slide, or more accurately, in the opposite direction of the force working/attempting to slide the object.

This study examined friction force definitions and explanations in a sample of textbooks, alongside knowledge of common student misconceptions confirmed by the existing literature. The misconceptions and inconsistencies among the definitions found in the books have been explained with examples. As a result, the authors propose a new definition, explaining the concept of friction force in more concrete terms for the purposes of science education. A more coherent and consistent explanation for determining the direction of friction force has also been introduced. Ideally, the results of this study will guide course developers and textbook authors, therefore shaping the conceptual development of teachers and students. However, one should note that the results are limited due to the small number and convenience factor in the sample of books chosen. Although the literature indicates that students have misconceptions about friction force, the current study does not quantify to what extent the use of friction force terminology influences these misconceptions. Therefore, future empirical studies should investigate how textbook terminology affects students' conceptualizations in science education, specifically in relation to the friction force concept and other building blocks of science knowledge.

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Appendix.Reviewed Books

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Cognitive Load in Multimedia Learning: An Example from Teaching about Lenses

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Abstract

Animations are widely used in today's science classrooms. Therefore it is very important to explore under which conditions animations are most effective. In earlier studies it has been generally shown that the effectiveness of instruction largely depends on management of cognitive load. The aim of the present study was to compare the effect of Physlet animations, printed sequences of selected animation frames and traditionally presented static pictures on understanding about lenses and levels of cognitive load. According to the results of a quasi-experiment that included forty nine high-school students, Physlet-based teaching generally leads to higher germane load and consequently to more effective learning than the traditional approach. Particularly high levels of germane load have been found for Physlet-based problems. These findings can be accounted for by the interactivity feature of Physlets.

Introduction

The use of interactive multimedia learning environments has increased significantly in the last decade (Fui-Theng & Mai, 2014). Interactive multimedia learning environments are believed to facilitate learner-engaged learning which is expected to lead to deeper cognitive processes and result in active construction of new knowledge (Kalyuga, 2008). According to Spector, Christensen, Sioutine, & McCormack (2001) it is exactly the interactivity feature of technology-enhanced learning environments which provides many opportunities for active cognitive engagement, reflection and feedback. However, the results of comparative studies about the impact of static and dynamic media on students' learning are mixed (Mešić, Dervić, Gazibegović-Busuladžić, Salibašić, & Erceg, 2015). Researchers are still trying to understand under which conditions and why interactive animations can enhance comprehension and learning more than static pictures (Lowe & Schnotz, 2008; Kühl, Navratil, & Münzer, 2018; Sudatha, Degeng, & Kamdi, 2018; Tversky, Morrison, & Betrancourt, 2002).

A valuable theoretical framework for understanding the effects of interactive animation on learning outcomes can be found in the Cognitive load theory (see Sweller, Ayers, & Kalyuga, 2011). According to Kalyuga (2008), dynamic interactive animations can help us to reduce the unnecessary load that is caused by inadequate instruction design or complexity of tasks, as well as to promote cognitive processes that are essential for learning. In order for the animations to facilitate learning, it is also important that their design takes into account the nature of learning of the corresponding subject matter (Rapp & Curby, 2008). An example of interactive animations whose design was inspired by findings from research on students' learning in physics are the Physlets (Christian & Belloni, 2001). Physlets are simple Java applets which cover most topics typically taught in introductory physics courses at the university level (Christian & Belloni, 2013). According to Krusberg (2007) Physlets are an extremely practical and flexible educational technology whose properties make them an invaluable tool in physics education.

However, empirically grounded evidence regarding the efficacy of Physlets-based teaching is rare. As a matter of fact, there were only a few studies about this topic (e.g., Mešić, Dervić, Gazibegović-Busuladžić, Salibašić, & Erceg, 2015; Ulen, Čagran, Slavinec, & Gerlič, 2014; Ulen, Gerlič Slavinec, & Repnik, 2017) and the authors of this article know of only one study (Lee, Nicoll, & Brooks) that systematically explored the efficacy of Physlet-based teaching from the perspective of Cognitive load theory. In the study by Lee, Nicoll and Brooks (2004) cognitive load has been applied for explaining why an worked example approach to using Physlets is more effective than an inquiry approach to using Physlets. However, they did not attempt to measure students' cognitive load and therefore could not establish precise relationships between cognitive load and type of learning materials. Our study was conducted with the aim of comparing effects of Physlets, printed sequences of static pictures generated from Physlets and traditionally presented static pictures on learning outcomes and cognitive load within the context of teaching about lenses.

Background

Cognitive Load Theory

The architecture of human cognition consists of an effectively unlimited long-term memory (LTM), which interacts with working memory (WM) that is very limited in both capacity and duration. According to Baddeley's (1992) WM model auditory information are processed in the ‘‘phonological loop” and visual information are processed in the ‘‘visual-spatial sketchpad”. Any conscious cognitive activity requires working memory capacity. The basic assertion of CLT is that instructional design needs to take into account the limitations of working memory in order to prevent an overload of working memory capacity and hence a deterioration of learning (Sweller, 2005). According to Van Merriënboer & Kirschner (2007), learning occurs if information is successfully processed in WM, which can lead to schema construction (creation of a new schemata), schema assimilation (incorporation of the new elements of information into existing schemas), schema elaboration (incorporation of elements consisting of lower level schemas into higher level schemas, resulting in more complex schemas) and schema accommodation (adaptation of existing schema based upon incongruous or inconsistent new information). According to CLT teaching material can induce three types of cognitive load in working memory. The first type of cognitive load, intrinsic cognitive load, is caused by the complexity of the information to be learned or problem to be solved. It depends on the number and interactivity of elements (symbols, concepts, procedures and rules) which simultaneously need to be processed in the working memory (Sweller, 1994). For example, memorizing individual foreign words is characterized by low element interactivity, while building sentences (i.e., combining multiple words) in a foreign language is an example of high element interactivity. The intrinsic load is defined in relation to the level of expertise of a learner (Sweller, Van Merriënboer, & Paas, 1998).

The second type of cognitive load, extraneous cognitive load, can be induced by an inappropriate presentation of the learning material as well as by requiring the students to perform activities that are irrelevant to learning. Generally, it is induced by all the unnecessary cognitive activities that do not contribute to schema construction and automatization (Sweller, 2005). For example, integration of information from spatially separate sources of information could increase extraneous cognitive load because information from one source needs to be maintained in working memory in order to integrate it with the information from the other source (Ayres & Sweller, 2005). Finally, the type of cognitive load that results from active schema construction processes, which promote learning, is germane load (Paas & Van Merriënboer, 1994). Actually, germane load is related to working memory resources devoted to the load imposed by intrinsic nature of the material (Sweller, 2005).

In learning settings with a high intrinsic cognitive load, reduction of extraneous cognitive load frees working memory capacity which can be used for relevant learning processes. However, if the intrinsic load is low learning can be successful despite a high extraneous load. For learning to be effective, the total amount of cognitive load associated with an instructional design should not exceed the available WM processing capacity (Paas, Tuovinen, Tabbers, & Van Gerven, 2003; Sweller *et al*, 1998; Van Merriënboer & Sweller, 2005). In a nutshell, when managing the total cognitive load to facilitate learning, extraneous load must be reduced, intrinsic load must be adjusted and germane load must be fostered (Paas, Renkl, & Sweller, 2003, 2004; Van Merriënboer, Kester, & Paas, 2006).

Cognitive Load in Multimedia Learning Environments

Multimedia can be defined as an environment that offers learners access to information in a variety of formats, such as text, still images, animations, video, and audio presentations. The design of multimedia should be consistent with the assumptions put forth by CLT according to which working memory consists of two independent systems for processing verbal and audio information (Baddeley, 1992). Considering that each system has a limited capacity to process information, multimedia can facilitate learning by reducing cognitive load through simultaneously presenting information to both systems (i.e. audio and text) (Chandler & Sweller, 1991; Mayer & Anderson, 1992; Mayer & Moreno, 1998; Mayer & Sims, 1994).

However, recent studies have demonstrated that this so-called multimedia effect is not universal, especially when the information are presented in the visual format through words and pictures. Learners often fail to integrate information from multiple sources which are being processed in the same channel. In fact, multiple representations could slow processing of information and reduce performance in both comprehension and knowledge transfer (Gerjets, 2010; Scheiter & Eitel, 2010; Schuler, Scheiter & Gerjets, 2010). Kalyuga (2008) noted that main sources of an unnecessary cognitive load in multimedia learning environments are spatially and/or temporally separated elements of information that need to be integrated. Furthermore, if one isolated piece of information is fully intelligible for the learners, then unnecessarily processing of an additional piece of information that has no additional benefit for understanding can result in extraneous cognitive load. Sweller & Chandler (1994) have called this ‘‘the redundancy effect’’. In addition to redundancy, the reason why the multimedia effect does not always positively influence learning can be found in the situation when there is a trade-off between processing of text and processing of pictures. According to Schnotz & Bannert (1999), the pictures might replace the text to some extent in the process of comprehension and learning and learner will use the pictures instead of the text, which results in less intensive processing of the text.

Cognitive load in processing of interactive animations

Whereas static pictures include only visual-spatial information, animated pictures include visual-spatial as well as temporal information. This defining feature of animated pictures could support construction of dynamic mental models. Animations allow a direct activation of dynamic perceptual schemata, which is not as easily achievable with static pictures (Schwan & Riempp, 2004; Tversky, Heiser, Mackenzie, Lozano, & Morrison, 2008).

However, animations are possibly not beneficial in all situations. Due to the quick loss of information in working memory, very limited processing can be devoted to the single states within the animation. Therefore, if the learner has to compare different states within a dynamic event, displaying the corresponding states simultaneously through static pictures would provide a much better basis for this kind of requirements (Betrancourt, 2005; Schnotz & Lowe, 2008). Kalyuga (2008) asserts that one of the main sources of overload in dynamic multimedia is the management of transient nature of dynamic information. The transient information should be kept active in working memory while simultaneously more upcoming information is being processed, which leads to overload of the working memory.

A recent development in multimedia learning environments is the use of interaction between the learner and the animation which is especially important in learning physics topics. For example, interactive animations can permit the learner to manipulate the frequency and intensity of light that is incident on a metal surface, when investigating how these two variables affect the emission of photoelectrons. In other words, interactive animation allow for testing of hypotheses about physical phenomena under specific conditions. One more desirable feature of interactive animations is that they allow the learners to control their own learning by controlling the pace of the animation (by speeding up or slowing down the rate of display) In addition, interactive animations sometimes allow learners to perform cognitive processes that had otherwise been very difficult to implement due to tasks that put high demands on the WM capacity (Rasch & Schnotz, 2009).

Interactive multimedia learning environments have the potential of more efficient management of cognitive load compared to traditional media. Kayluga (2008) suggests several ways in which interactivity in multimedia learning environment contributes to the management of various sources of cognitive load. First of all, it should be noted that providing feedback on student responses facilitates development of deep understanding of the material, whereby explanatory feedback is to be preferred over corrective feedback (Johnson & Priest, 2014). As a matter of fact, explanatory feedback may assist in balancing the executive functions between existing knowledge and instructional guidance (Kayluga, 2008). As learners acquire more experience the focus of instruction moves from detailed explanations to problem-solving or exploration, which in turn further increases learner expertise. However, interactive exploratory learning environment can be very demanding and may generate cognitive overload for novice learners. An interactive learning environment that includes communicational level of interactivity can increase germane load, by prompting the learners for self-explanation and prediction.

Physlets

Physlets are small, flexible and interactive animations whose design was guided by the results of physics education research (Christian & Belloni, 2001). Christian & Belloni (2013) have developed a broad collection of Physlets that cover almost all introductory physics topics typically taught at the university level. This collection of Physlets can be accessed freely at https://www.compadre.org/physlets. Physlets allow for multimodal learning by demonstrating the physical phenomena through vivid visualizations, accompanied by providing the corresponding graphs, diagrams and tables. According to Krusberg (2007) presenting of a physics concept by combining multiple representations promotes development of conceptual understanding. In addition, it should be noted that Physlets allow the students to control their own pace of learning – typically, students can easily start and stop animations, collect measurement of various quantities and control the position of objects within the active window. Since physics deals often with dynamic phenomena, Physlets are in general in line with the principle of congruence (Tversky, Morrison, & Betrancourt, 2002), according to which the content and form of teaching materials should correspond to the contents and form of the presented concept.

For each topic of introductory physics the Physlets collection contains three types of Physlets (Christian & Belloni 2004): illustrations, explorations and problems. Physlet-illustrations are mainly aimed for facilitating the introduction of new physical concepts within the context of vividly represented physical phenomena. Physlet-explorations allow further investigation of the introduced physical concept. They are mostly designed in line with the idea of guided inquiry, with worksheets provided for all explorations. Thereby, learners are expected to set and test hypotheses about physical phenomena, and to explore relationships between physical quantities, in general. For learning about optical elements most Physlet-explorations are situated within the context of experimenting with various objects (point sources, beam sources, mirrors, lenses) on an optical bench, whereby light rays are used for explaining the creation of optical images and the user is allowed to take measurement of coordinates for purposes of gathering information about the relevant distances.

Finally, Physlet-problems represent problems in which at least part of the problem-stem is provided in the form of an animation. Here students are typically expected to analyze the dynamic visualization of a given phenomenon with the purpose of finding the unknown value of a physical quantity or to find the relationship between various quantities. While interacting with Physlet-problems students receive much less external guidance compared to the use of Physlet-explorations. Figure 1 shows a screenshot from Physlet-problem 33.1 which is related to the topic of concave mirrors.

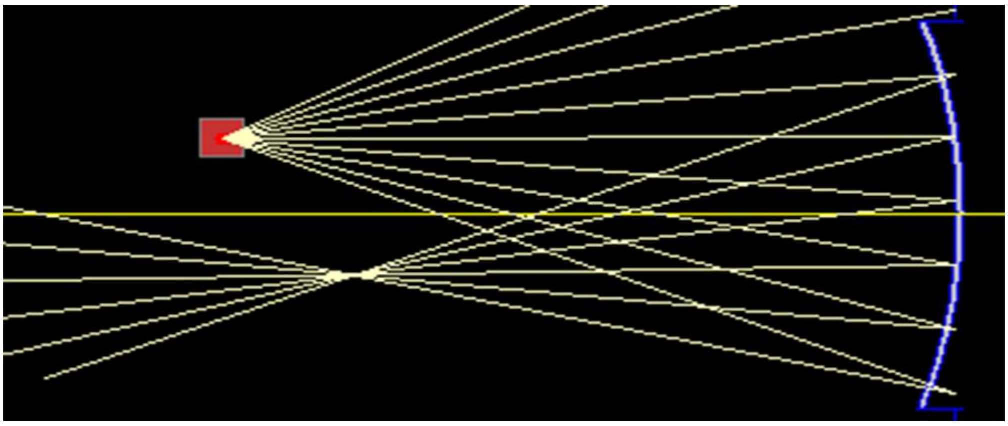

Figure 1. Exploring the focal length of curved mirrors with Physlets

In the above mentioned example the learner is expected to find the focal length of a given concave mirror, whereby the learner is shown a divergent beam of light rays emanating from a light source which can be freely moved to any position in the animation window. The learner is expected to realize that only light rays that are passing through the focal point are parallel with the optical axis after being reflected from the mirror. Such a situation is obtained when the source of the divergent light beam is dragged to the position of the focal point. Now it is sufficient to read the coordinates of the mirror and the light source in order to find the distance between these two objects which in this particular situation represents the focal length of the mirror. It should be noted that compared to traditional physics problems, Physlet-problems better resemble real-world problem situations. As a matter of fact, in the verbal part of the Physlet-problem stems typically it is being avoided to explicitly provide information about the type of object's motion, as well as about the values of relevant physical quantities. However, the visual part of the problem stem provides means to access more information than it is needed for solving the problem. Thereby, from a large amount of information (much of these being redundant) the learner has to identify relevant information, collect measurements and analyze the collected data for purposes of solving the problem (Dancy, Christian, & Belloni 2002).

There are only a few journal articles that describe pedagogical features of Physlets and/or effects of Physlet-based teaching. Bonham, Risley, & Christian (1999) described the use of Physlets in teaching electrostatics, Cox, Belloni, Christian, & Dancy (2003) in thermodynamics, Dancy, Christian & Belloni (2002) in optics and Belloni, Christian, & Cox (2007) in quantum mechanics. Cox *et al* (2003) found that the use of Physlets has the following advantages for teaching thermodynamics: 1) allows interactive visualization of abstract concepts; 2) stimulates students to use more advanced problem-solving strategies; and 3) provides the possibility of direct insight into the effect of applying a change of system parameters. Results of the studies conducted by Ulen, Čagran, Slavinec, & Gerlič (2014) and Ulen, Gerlič Slavinec, & Repnik (2017) indicate that Physlets contribute to conceptual learning more than traditional teaching. Similar results were obtained in the study conducted by Mešić, Dervić, Gazibegović-Busuladžić, Salibašić, & Erceg (2015).

Research on Teaching and Learning about Lenses

Earlier research shows that many student have misconceptions about the mere mechanism of image formation by a lens. Knight (2004) comments that a substantial number of students think there is a "potential image" that travels as a whole from the object to the screen where it is given realization. Therefore it is important to consistently use the point-to-point correspondence between object and image when explaining image formation by a lens (Viennot, 2003). To that end it is advisable to point out that light rays emanate from all points (and in all directions) of a bright object (Arons, 1997). It is also important to emphasize that image is formed by a lens no matter whether there is a screen or not (see Goldberg & McDermott, 1987). Knight (2004) suggests that effective teaching about lenses should take into account students' difficulties with the ray model of light, as well as to include a clarification of the role of principal rays, the lens and the screen in image formation. Finally, it is also important to explain the role of the eye in "seeing the image".

Present Study

Tversky, Morrison, & Bétrancourt, (2002) suggest that „*interactivity may be the key to overcoming the drawbacks of animation as well as enhancing its advantages*" (pp. 258). The interactivity of Physlets allows the learner to control different aspects of the visual display. They can view and review, stop and start, change key values, monitor effect of the changes, and study all aspects of the visual display that they need. In addition, interactivity allows the learners to take active role in their learning. Compared to static pictures, interactive animations can stimulate more elaborated cognitive processing. Physlets are particularly suitable for exploring the point-to-point correspondence between object and image which proves to be very important for developing understanding about image formation by lenses (Viennot, 2003). It also allows for tracing a large number of light rays emanating in different directions from one and the same point of the object. According to Arons (1997, p. 260) showing a divergent bundle of rays emitted from each object point may help the students to develop a better understanding about the process of image formation.

When it comes to the traditional framework of learning it should be noted that it is based on the assumption that knowledge is transferable through verbal explanation of the learning material to students who are more or less passive listeners. Due to practical reasons, in traditional static visualizations typically only the principal light rays are traced which sometimes results in poor understanding of the role of principal rays in image formation (Knight, 2004). Therefore interactive animation can be a more efficient learning environment compared to traditional, expository instruction. However, interactive animation may require additional cognitive resources. Therefore, generally, it can be assumed that interactive pictures create additional extraneous load which potentially impedes learning. Consequently, *the first aim of our study was to investigate the relative efficacy of using Physlets, printed sequences of static pictures generated from Physlets and traditionally presented static pictures for facilitating learning about lenses.*

Interactive multimedia learning environments have the potential of more efficient management of cognitive load and thus more efficient learning. According to Schnotz & Rasch, (2005), interactive animation could have enabling, facilitating or detrimental function. The enabling function manifests itself in the situation when animation reduces the cognitive load in order to allow cognitive processing that would otherwise be impossible. If the task could be solved only with high mental effort and interactive animation reduces cognitive load of task, then animations will have a facilitating function. Therefore, one could assert that interactive animation reduces extraneous cognitive load and create additional germane load. However, interactive animation may also impose additional cognitive load due to the need of making decisions about which manipulations should be executed and additional search processes, in general. Consequently, interactive animations may also have a detrimental function, manifested in an increase of extraneous cognitive load and reduction of germane load. When it comes to intrinsic load, it should be noted that it is determined by the complexity of the information to be learned or problem to be solved. Therefore, it can be assumed that the same structure of learning material across different teaching methods (Physlets, printed sequences of Physlets-based pictures, traditionally presented static pictures) imposes the same intrinsic cognitive load, given that learners have equal prior knowledge. In line with these assumptions, *the second aim of our study was to investigate the effects of using Physlets, printed sequences of static pictures and traditionally presented static pictures on intrinsic, extraneous and germane cognitive load.*

Methods

Participants

Our study included 49 high-school students from three parallel school classes at the Sarajevo Second Gymnasium (Bosnia and Herzegovina). The sample has been obtained by means of convenience sampling. The average age of the participants was 16.14 years (SD = 1.25) and 53.7 % of participants were female. Seventeen students from one randomly selected class were taught with Physlets. Another fifteen students from the second randomly selected class were taught with sequences of Physlets-based static pictures. Finally, the third group consisted of seventeen students who received the traditional treatment characterized by traditional presentation of static pictures.

Materials

In the three treatment groups different learning materials were used. Within the traditional treatment group the students learned from static pictures that were drawn on the blackboard. In the two remaining groups, students learned from Physlets (Christian & Belloni, 2013) and from printed sequences of Physlets-based static pictures, respectively. All learning materials presented the same learning topic which was lenses. This topic was part of the regular curriculum. For all treatment groups, we prepared learning materials in which illustrations are followed by explorations and problems. The purpose of illustrations was to vividly introduce the most important concepts. On the other hand, explorations were supposed to facilitate exploration of specific physical phenomena, and problems were expected to provide effective contexts for elaboration and application of knowledge.

Physlets

Physlet–based learning materials were obtained from the second edition of the Physlet physics book (Christian & Belloni, 2004) that can be freely accessed at: https://www.compadre.org/physlets/. In total, eleven Physlets from the above mentioned book were used in the classes: two Physlet-illustrations (convex and concave lenses), five Physlet-explorations (characteristic rays, focal length, distance between figure and curvature of lens, position of image with respect to object's position) and four Physlet-problems (image formed by convex lens, focal length of convex lens, point sources and beam sources of light, systems of two convex linses).

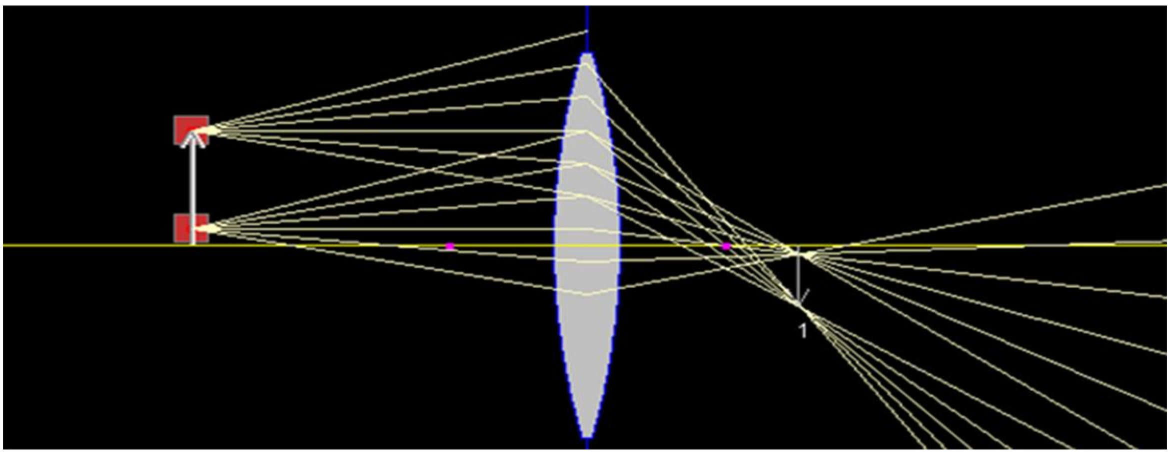

Figure 2. Exploring the image formation by a convex lens for an extended object

Figure 2 shows a screenshot from a simulation in which the learner has on her/his disposal an optical bench, a bright object and a biconvex lens. This simulation allows exploration of image formation by a converging lens.

Concretely, the learner is allowed to move the bright object along the optical bench and to observe how moving the object affects the position and height of the image. As the object is moved along the optical bench the learner can observe how the ray diagram changes. Quantitative conclusions about image formation can be drawn by measuring the coordinates of object, lens and image. Thereby, learners were guided through exploration activities through the use of corresponding worksheets that are part of the Physlets-package.

Sequences of Physlets-based static Pictures (static Physlets)

Similar to animated cartoons, each Physlet inherently contains an enormous number of static pictures associated with the different states of the simulated physical system. For example, the user can change the position of an object in multiple ways which results in multiple different positions of the object's image. In one of the treatment groups, the learning material was obtained by extracting from each Physlet multiple static pictures (typically 3 or 4 pictures) that showed those states of the animated system that we considered to be most relevant for learning.

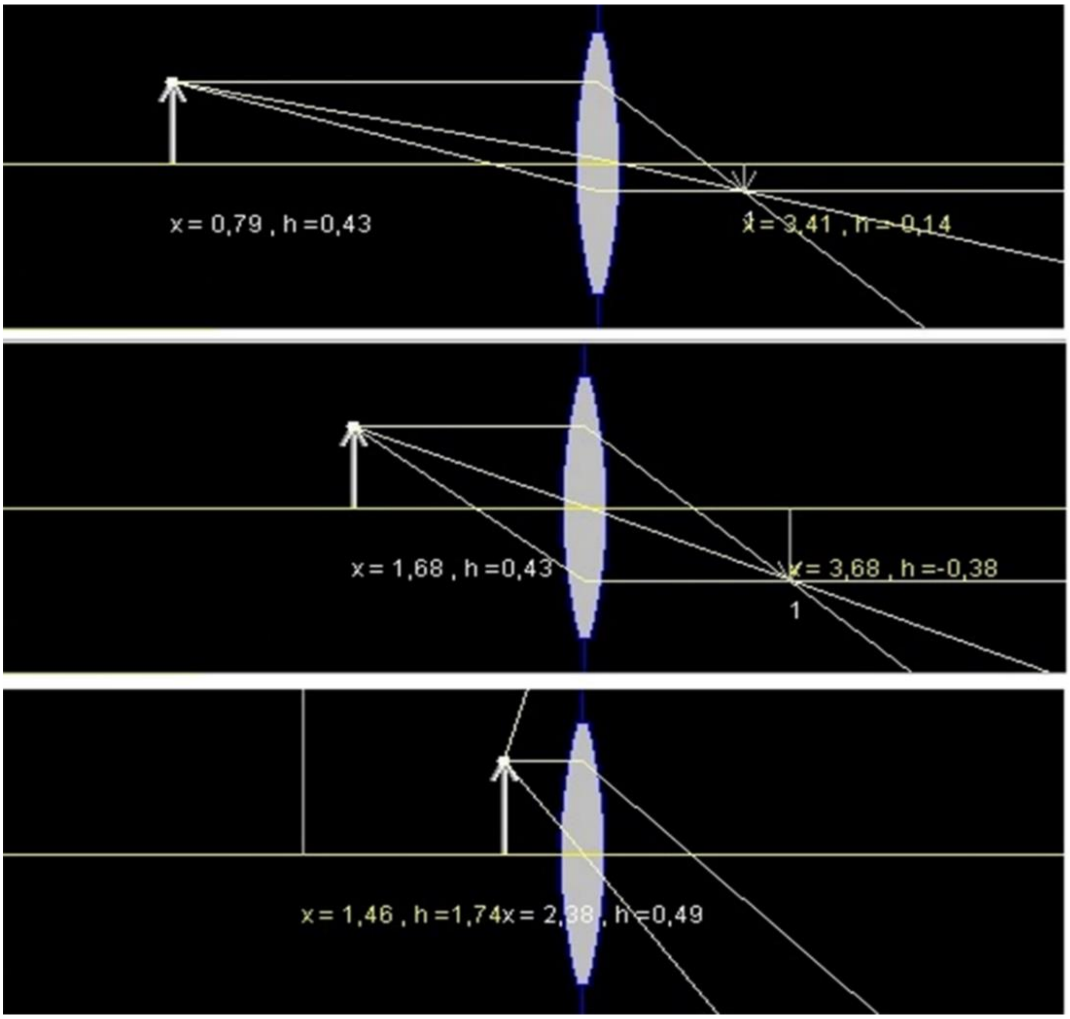

Figure 3. A sequence of static pictures generated from a Physlet animation

Figure 3 shows the sequence of three static pictures that illustrate three characteristic "object-image" situations generated from the earlier discussed optical bench Physlet. The three pictures were generated by means of the print screen feature. These sequences of static pictures were available to students in printed form, whereby the sequences related to explorations were accompanied with worksheets and the sequences related to problems were accompanied with the written version of the problem stem. The nature of the learning material did not allow the students to interact directly with the teaching material. Although the students could not interact with this type of visualization in the way it was possible with dynamic Physlets, they could infer the cause and effect relationships from the visualizations that were pre-prepared for them by the teacher.

Traditional static pictures

Traditional static pictures were drawn by the teacher on the blackboard. The teacher drew on the blackboard pictures that can be considered as traditional analogues of pictures that were provided in printed form to the static Physlets group. In some occasions simply the sequences of pictures that were provided to the one group in printed form were drawn on the blackboard for the traditional group. For example, for purposes of illustrating image formation by a lens, on blackboard the three illustrations from Figure 3 were drawn. However, in most other occasions the teacher attempted to represent a physical situation within a single picture (instead of using a whole sequence of pictures) which is typical for the traditional approach. An additional difference between the traditional approach and the two earlier described approaches was that students from the traditional group were not provided with worksheets that guided the analysis of some visualizations in the other two groups. As a matter of fact Physlets-based explorations are accompanied with worksheets that may guide the learner through the process of taking measurements and analyzing data. In other words, Physlet-based materials (both, dynamic and static) prove to be more compatible with the guided inquiry instruction because they explicitly include the requirement of analyzing (visual) data with the purpose of constructing new knowledge.

Measures

Prior knowledge

As a measure of physics prior knowledge the half-year report grades in physics were used. The range of grades was between 3 to 7 on a scale from 1 to 7. The arithmetic mean was M=4.67 (SD=1.07). Analysis of variance showed that the between-group difference in average physics grades was not statistically significant ($F(2,46)=1.03$, $p=0.36$). Bonferroni *post hoc* analyses showed that for none of the multiple comparisons (Physlets vs static Physlets, Physlets vs Traditional, Static Physlets vs Traditional) a statistically significant effect could be found.

Cognitive Load Questionnaire

The intrinsic, extraneous and germane cognitive load were measured by an instrument initially developed by Leppink, Pass, Van der Vleuten, Van Gog, & Van Merrienboer (2013). That instrument consists of ten items. Thereby, three items measure intrinsic, three extraneous and four germane load. The results of a study conducted on a sample from Bosnia & Herzegovina (Zukić, Đapo, & Husremović, 2016) indicate satisfactory validity and high reliability of the instrument. In our study the Leppink's instrument has been administered three times – after illustrations, explorations and problems, respectively. For the germane load subscale Cronbach's alpha amounted to 0.8, 0.92 and 0.95, while for the extraneous load it amounted to 0.46, 0.63 and 0.63. Finally, for intrinsic load the Cronbach's alpha amounted to 0.69, 0.84 and 0.69, for the three chosen time points.

Table 1. A brief description of posttest items

Item 1	**Item 2**	**Item 3**	**Item 4**	**Item 5**	**Item 6**	**Item 7**
Determining the type of lens from the visual representation of light ray propagation though a "black-box"	Describing image (nature, position, height) for different distances of the object from the biconvex lens	Determining the type of lens from the visual representation of light ray propagation through a "black-box" (multiple boxes)	What is the focal length of the concave lens (object and image position explicitly provided)?	What is the focal length of the lens system (focal lengths of individual lenses and their separation explicitly provided)?	What is the focal length of the lens system? (focal lengths and their separation must be inferred from a picture before calculation)	Construct a ray diagram for the given object and concave lens and discuss the characteristics of the obtained image
Multiple-choice	Two-tier multiple-choice	Two-tier multiple-choice	Open-ended	Open-ended	Open-ended	Open-ended

Knowledge test (learning outcome)

Students' learning outcomes were examined by a *Knowledge test* which was constructed for the purpose of this study. It consists of seven items and measures students' understanding about lenses. A brief description of the test items is provided in Table 1. Generally, we attempted to align the test items with contents that had been covered within the teaching treatments. Each completely correct answer was credited with one point which means that, theoretically, the posttest scale ranged from 0 to 7. There was no time limit imposed for completing the test.

Procedure

The study was conducted in one learning session lasting about 90 minutes for each group. For each group, the session consisted of three parts: firstly illustrations were shown, followed by explorations and problem-solving activities. The pictures, animations and drawings were accompanied by the spoken instruction and explanation. During Physlet-based sessions, presentations were projected on the screen, while teacher and volunteering students altered parameters and interacted with Physlets. The teacher started and guided the discussion. The students participated in the discussion and entered their predictions, observations and conclusions into their worksheets (for exploration activities).

In the approach characterized by use of sequences of static Physlet-based pictures, the students got the printed version of static Physlet-pictures and the same worksheets as the students from the Physlet group. Unlike students from the Physlet group, in the "sequences of printed pictures" group students were not able to track the dynamic consequences of altering parameters of the physical setting. For example, in the Physlet group one could change focal lengths of lenses (in infinitely many ways) and observe how this affects refraction of the beam in "real-time", while in the sequences of static pictures group the students were only presented with a few printed images showing refraction on lenses that have different focal lengths.

In the traditional teaching group visualization of concepts was achieved by using the blackboard. The teacher adapted examples of physical situations so that they matched as close as possible the examples used in the Physlets-based treatments. The problem-solving sessions in the traditional group were different compared to corresponding sessions in the other two groups. Specifically, for each problem, only one student was asked to solve the problem on the board, in front of the class, whereas other students were expected to analyze the modeled problem-solving process and to compare it with their own ideas. After each session part (illustration, exploration and problems) students in all groups completed the Instrument for measuring intrinsic, extraneous and germane cognitive load. At the end of the learning session, students also completed the Knowledge test.

Results

The Effect of Teaching Method on Learning Outcome

For purposes of investigating the effect of teaching method (traditional, static Physlets, Physlets) on understanding of lenses we conducted a one-way ANCOVA, controlling thereby for the effect of students' prior knowledge. Figure 4 illustrates the effect of different teaching methods on students' level of understanding about lenses. On average, students from the Physlet-groups scored 84,0 % on the optics test, while students from the groups who used static Physlet pictures and a traditional approach scored 68.5 % and 63.8 %, respectively.

The main ANCOVA analysis has been preceded by an exploration of the relationship between students' previous knowledge and students' level of understanding of lenses. Thereby, the Pearson's coefficient of correlation ($r=0.358$; $p=0.012$) was found to be moderate and statistically significant which justifies the inclusion of the covariate into the statistical model. Our data met the ANCOVA assumptions. Specifically, it has been found that the covariate is independent of treatment effects (level of prior knowledge was the same across the three teaching methods) ($F(2, 46)=1.032$; $p=0.364$). In addition, our data also met the homogeneity of regression slopes assumption (regression slopes for the relationship between level of understanding and previous knowledge were the same across groups) ($F(2,48)=0.427$; $p=0.655$), as well as the homogeneity of error variances assumption ($F(2,46)=2.365$; $p=0.105$). We found a statistically significant effect of teaching method on the level of understanding about lenses, after controlling for effects of previous knowledge ($F(2,48)=8.316$, $p=0.001$, partial $\eta^2=0.27$). Bonferroni *post hoc* analysis showed statistically significant differences between the traditional teaching methods and Physlets-based method (p=0.001), whereas the difference between the Physlets-based method and static Physlets was (barely) not statistically significant (p=0.063). A comparison between the traditional teaching method and static Physlets method showed that the difference in level of understanding about lenses proved to be statistically non-significant (p=0.424).

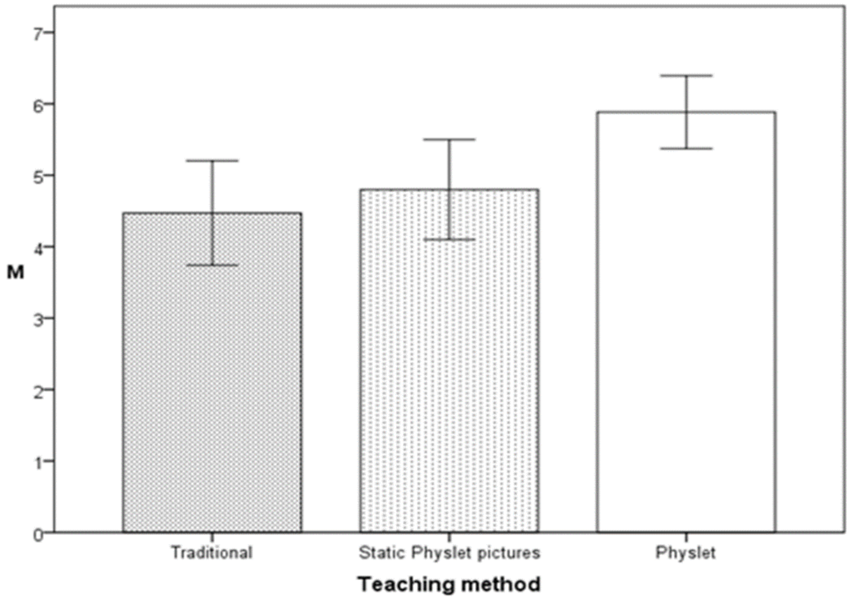

Figure 4. Means and corresponding 95 % confidence intervals of the mean on the knowledge test about lenses for each teaching method

The Effect of Teaching Method on Cognitive Load

In order to investigate the effect of teaching method (traditional, static Physlets, Physlets), category of instructional content (illustrations, explorations and problems) and type of cognitive load (intrinsic, extraneous, germane) on self-reported cognitive load, a mixed ANCOVA was conducted. The categories of instructional content (illustration, exploration and problem) and type of cognitive load (intrinsic, extraneous and germane) were within-subjects factors and teaching method (traditional, static Physlets, Physlets) was between-subjects factor. For purposes of controlling for the effect of prior knowledge on cognitive load, we calculated the Pearson's correlation coefficients between half-year report grades in physics and self-reported cognitive load as measured by the Cogntive load questionnaire. Taking into account that these correlational analyses resulted with low and statistically non-significant correlations we decided not to include a covariate into the statistical model. Mauchly's sphericity test has been used for purposes of exploring the assumption of homogeneity of error variance. The Mauchly's test proved to be statistically significant for type of cognitive load ($\chi^2(2)=0.644$; p=0.0005; ε=0.737), and interaction between type of cognitive load and category of instructional content ($\chi^2(9)=0.520$; p=0.001; ε=0.777), whereby ε is Greenhouse-Geisser estimate of sphericity. Consequently, for the type of cognitive load variable a Greenhouse-Geisser correction of degrees of freedom has been applied, whereas for the interaction between type of cognitive load and category of instructional contents we applied the Huynh-Feldt correction of degrees of freedom.

For type of cognitive load a statistically significant main effect has been found, F(1.475,67.838)=59.879, p=0.005. The mean value of germane load (M=6.46) proved to be substantially higher compared to the mean value of intrinsic (M=3.192) and extraneous load (M=2.956). Bonferroni *post hoc* analysis indicated that germane load was significantly different from intrinsic (p=0.0001) and extraneous load (p=0.0001). We found no statistically significant difference between intrinsic and extraneous load.

Furthermore, the interaction between type of cognitive load and teaching method proved to be statistically significant, F(4,92)=3.627, p=0.009. Mean values of three types of cognitive load for the three teaching approaches are shown in Figure 5. Bonferroni *post hoc* analyses have been applied for investigating the statistical significance of simple main effects of the teaching method variable at different levels of the type of cognitive load variable. The only statistically significant effect (p=0.014) has been found for germane load comparison between the traditional and Physlet teaching methods.

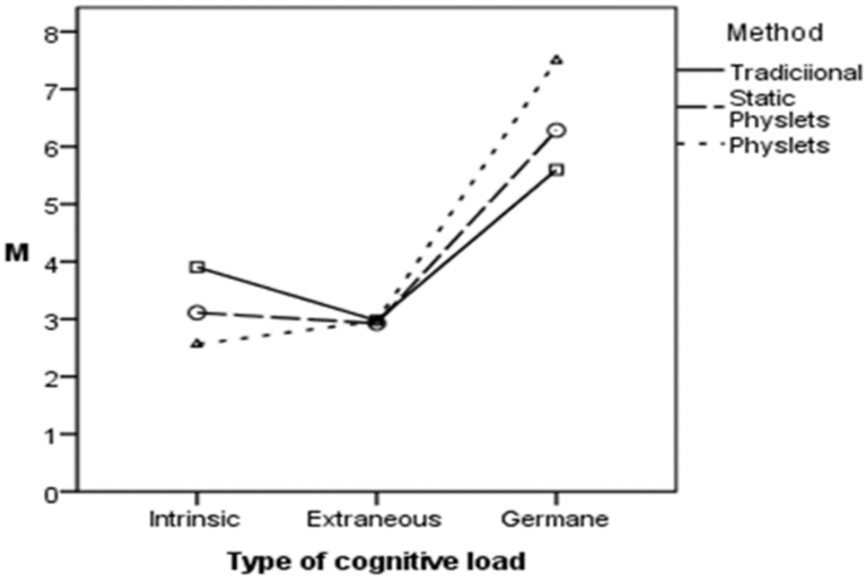

Figure 5. Mean values of three types of cognitive load for each teaching approach

We have found neither a statistically significant effect of category of instructional content ($F(2,92)=0.446$; $p=0.642$), nor a statistically significant interaction between category of instructional content and teaching method ($F(4,92)=1.353$; $p=0.257$). On the other hand, the interaction between type of cognitive load and category of instructional content proved to be statistically significant, $F(4,184)=4.554$; $p=0.002$. Figure 6 shows the mean values of different types of cognitive load at different levels of the instructional content variable. We conducted Bonferroni *post hoc* analyses of simple main effects of the type of instructional content variable at each of the levels of the type of cognitive load variable. Statistically significant differences have been found for the illustration versus problems comparison ($p=0.009$), as well as for the exploration versus problem comparison ($p=0.029$). In addition, it has been found that illustrations significantly differ from problems, when it comes to the induced germane load ($p=0.024$).

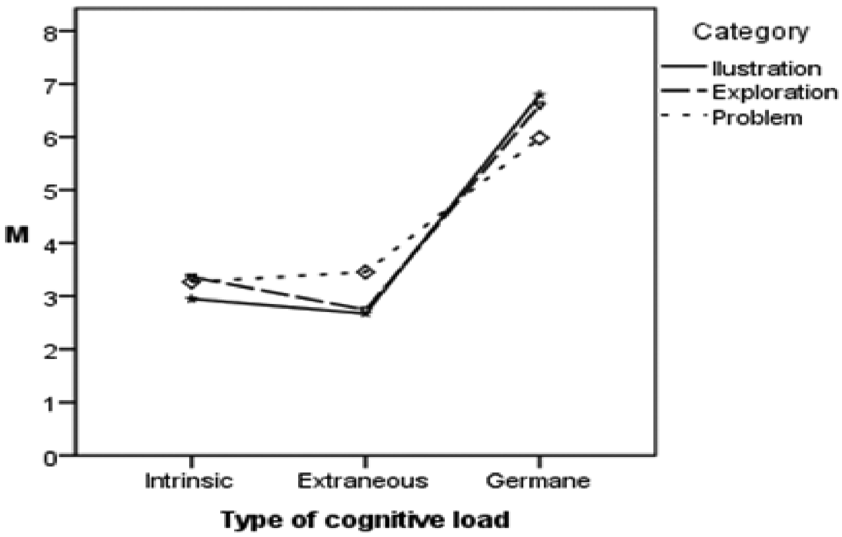

Figure 6. Mean values of type of cognitive load at the three levels of instructional content

Finally, we have found a statistically significant interaction between the type of cognitive load, category of instructional content and teaching approach, $F(8,184)=4.797$, $p=0.0001$; $\eta^2=0.173$. Figure 7 shows the mean values of the three types of cognitive load for the three teaching approaches, at each of the three levels of the instructional content variable.

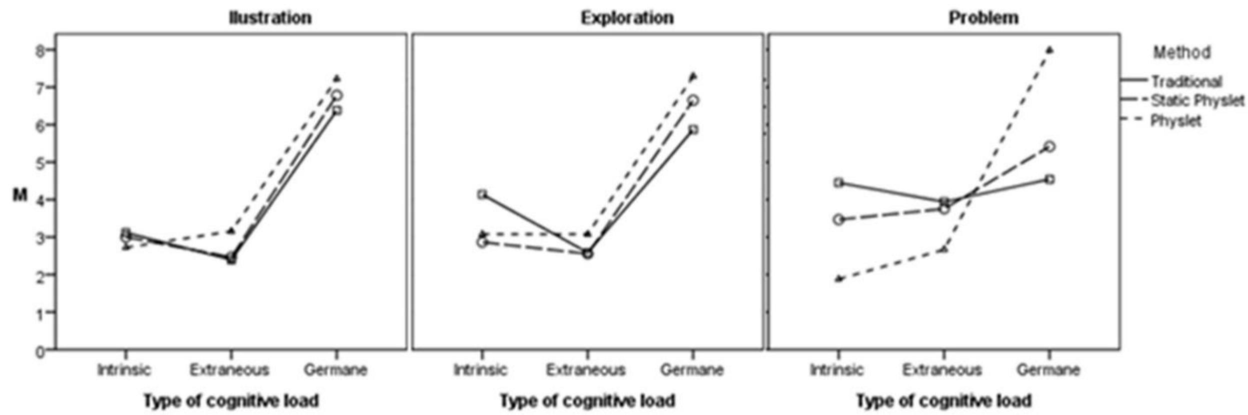

Figure 7. Mean values of the three types of cognitive load for the three teaching methods, at each of the three levels of the instructional content variable

For each of the instructional content categories Bonferroni *post hoc* analyses have been conducted with the purpose of exploring the statistical significance of simple main effects of the teaching approach variable at each level of the type of cognitive load variable. Unlike for illustrations and explorations, for the problems category we have found statistically significant interactions between the teaching approach and type of cognitive load. When it comes to problem-solving, the lowest intrinsic load has been found for teaching with Physlets. Intrinsic load for solving Physlet problems was significantly lower than intrinsic load related to solving problems in the traditional ($p=0.0001$) and static Physlets approach ($p=0.041$). Just the opposite pattern has been found for germane load. The germane load related to solving Physlet problems was significantly higher than germane load related to solving problems in the traditional ($p=0.001$) and static Physlets approach ($p=0.023$).

Discussion

The first objective of our study was to compare the effectiveness of the Physlet-based approach to teaching about lenses with the traditional and static Physlet approach. It has been found that Physlets-based teaching about lenses is more effective compared to the traditional approach. Similar findings were reported by Ülen *et al* (2014) for teaching about electricity and Mešić *et al* (2015) for one-dimensional kinematics instruction. As a matter of fact, the animations allowed the learner to conduct virtual experiments with object and lens on an optical bench which helped them to develop better understanding about the point-to-point correspondence between object and image (see Viennot, 2003). Some Physlets also allowed tracing of a large number of light rays emanating from different points of an object, as well as observing how changing the focal length of a lens influences the propagation of these rays. Analyzing the propagation of a large number of rays probably helped the students to better understand the role of principal rays (Arons, 1997). However, Physlets-based teaching about lenses did not prove to be more effective compared to the approach that utilized sequences of static images, which was not in line with our expectations. This is in line with the results of some earlier studies which indicate that in certain contexts animations are not preferable to static instructional contents (Lewalter, 2003; Mayer, Hegarty, Mayer, & Campbell, 2005; Mešić *et al*, 2015; Swezey, 1991). A detailed theoretical account of this effect has been provided by Tversky, Morrison and Bétrancourt (2002). They emphasize the importance of congruence principle which says that the content and form of graphical representations should correspond to the content and form of the taught concept. Consequently, graphical animations are more effective if they are used for purposes of describing spatio-temporal changes. However, according to Tversky, Morrison and Bétrancourt (2002), animations often are not in line with the congruence principle which can explain the results of some studies that show no significant benefits of animations over static images. Furthermore, sometimes animations are not in line with the apprehension principle, which states that structure and content of the external representation need to be timely and correctly perceived and comprehended. Even for relatively simple situations that, for example, include observing the trajectory of a single body, the perception of the observed motion can be flawed (Caramazza, McCloskey, & Green, 1981; McCloskey, 1983a,b). Furthermore, sometimes animation is perceived by the student as a sequence of discrete events (e.g., Hegarty, 1992; Zacks *et al*, 2001). If the mere motion is also perceived by the students as a sequence of discrete steps instead as a continuous change, then it is advisable for the content to be presented through a sequence of discrete steps instead through an animation. Tversky *et al* (2002) conclude that animations sometimes are too complex or presented too fast, which is the main reason why animations sometimes are not more effective than static visual contents. This is particularly true when animations are used for representing complex systems. For representing continuous changes well-prepared sequences of static diagrams can be equally effective as animations. Various authors emphasize that some of the limitations of animations can be overcome by the feature of interactivity. As a matter of fact, the possibility to control the animations (e.g., stop, start, step forward, restart) makes it possible to repeatedly inspect some parts of the animation, as well as to focus on specific parts and actions. Animations that allow for interactivity and control can contribute to ensuring a more valid perception and better understanding, in general. However, the results of our study show that in certain contexts even interactive animations are not always preferable to sequences of static images, especially when such images have the potential of activating multiple learning processes (e.g., measuring, goal-directed analysis etc).

The second objective of this study was to investigate the effects of the teaching methods on cognitive load. Firstly, it should be noticed that generally germane load has been found to be significantly higher than the intrinsic and extraneous load. Since germane load is associated with cognitive processes that contribute to learning, the above-mentioned finding could be related to students' satisfactory physics previous knowledge in general, and optics knowledge in particular. Regardless of teaching approach, having the appropriate prior knowledge facilitated comprehension of instructional activities and cognitive engagement. An additional argument for the above-mentioned claim is related to the fact that students' previous knowledge was significantly related to students' achievement on the posttest (i.e., knowledge and understanding about lenses). According to the cognitive load theory, intrinsic load, on the one hand, depends on the number of elements and their interactivity, and on the other hand it depends on students' prior knowledge (Sweller *et al*, 2011). In our study, an appropriate level of students' previous knowledge led to an optimal level of intrinsic load and relatively high germane load.

Exploration of the interaction between type of cognitive load and teaching methods leads us to the interesting conclusion that germane load is significantly higher for the Physlets-based approach than for the traditional approach, but it is not higher than germane load for the approach that is based on presenting sequences of static images (i.e., static Physlets method). Although intrinsic load is highest for the traditional approach and lowest for the Physlets approach, no statistically significant effect could be detected. In addition, a nearly identical level of extraneous load has been found for all three teaching approaches. These results are in line with the cognitive load principle according to which in multimedia learning extraneous load can be lowered through integration of information and schema building (Brünken, Steinbacher, Schnotz, & Leutner, 2001; Mayer, 2001). Learning is more facilitated when contents are presented in a way that allows for simultaneous processing of auditory and visual sensory modalities, compared to the situation when contents are only presented through a visual modality (Mayer, 2001). Teaching about lenses primarily required combining visual contents with narratives, whereby there was no need for textual content similar or identical to the narrative. Consequently, the visual channel was not overloaded. All three teaching approaches were in line with that principle which made the level of extraneous load not to differ between the three approaches. On the other hand, the finding that Physlet animations and sequences of static Physlet images induce the same germane load is in line with conclusions by Tversky *et al* (2002), who emphasize that the efficacy of the dynamics multimedia environment depends on the mere topic that is being taught. Typically, in geometrical optics, the focus is not on observing spatio-temporal changes, which means that a well-prepared sequence of static images can be equally effective as the corresponding animation. The finding that post-treatment understanding of lenses was equal for these two teaching approaches is in line with the result that both approaches led to the same level of germane load. In both approaches the same amount of cognitive resources has been assigned to handling the learning activities and comprehending of physics contents. However, it should be also noticed that, compared to the traditional teaching approach, the Physlet animations and sequences of static Physlet images lead to higher germane load. Sequences of static images were carefully prepared with the purpose to show several characteristic situations that were most relevant for conceptualization of the physical phenomenon (e.g., different characteristic positions of the object on the optical bench). Consequently, these sequences of static images led to the same level of active learning as Physlet animations.

In addition, a statistically significant interaction between type of cognitive load and categories of instructional content has been found. Regardless of teaching method, the extraneous load was found to be significantly higher for problems than for illustrations and explorations. Furthermore, germane load was higher for illustrations than for problems. According to the cognitive load theory, for novices in a certain field problem-based learning can lead to a high extraneous load, and consequently to a low germane load, which hinders effective learning.

Finally, it has been found that the intrinsic load for problem category of instructional content of the Physlets-based method is significantly lower than in the traditional and static Physlets approach. Just the opposite effect has been found for germane load: germane load is significantly higher for the problem category of instructional content of the Physlets-based method than for the other two teaching methods. Physlets-based teaching facilitates development of conceptual understanding, particularly within the context of explorations and illustrations. Consequently, students enter the problem solving process with a higher level of knowledge, or at least with a higher level of self-effectiveness, what results with intrinsic load being lower and germane load being higher for the Physlets-based approach compared to the traditional and static Physlet approach. In addition, these findings can be accounted for by the interactive feature which can be only found within the Physlets-based approach. As we have already stated, problem-solving is a cognitively demanding task that typically leads to high extraneous load. However, it seems that the use of interactive simulations motivated the students to engage in minds-on processes and to intensively participate in discussions related to problem-solving. According to Paas, Renkl and Sweller (2003) by assigning the students a more active role in organizing their learning processes, we can motivate them to invest more mental efforts which potentially leads to a higher germane load. For students who learn within collaborative environments the cognitive load induced by the task can be shared between multiple students which decrease the level of cognitive load.

There are some limitations to this study. The first limitation of our study is due to the chosen technique of measuring cognitive load. Measuring of a cognitive load by means of self-report scales is based on the assumption that people have valid insight into their own cognitive processes, and that they are capable to report on the amount of invested cognitive effort. However, subjective estimates often can lead to different, event contradictory results (see de Jong, 2010). Although the *Questionnaire for measuring cognitive load* has satisfactory construct and predictive validity (Leppink *et al*, 2013; Zukić, Đapo, & Husremović, 2016), in future research we suggest using direct measures of cognitive load. The second limitation of this study is related to our sample size. As a matter of fact, larger samples are needed if we wish to increase the power of the statistical tests. Due to the relatively small sample size in our study, we were not in the position to conduct moderation analyses for purposes of investigating the relationship between different types of cognitive load and level of understanding about lenses in function of the teaching approach. Moderation analyses could certainly give additional value to our study. That is why in our future research we plan to include larger sample sizes. Finally, it would be also interesting to investigate whether the relative efficacy of Physlets, static Physlets and traditionally presented static pictures is moderated by the physics content variable.

Conclusion

Physlet-based teaching about lenses leads to higher germane load and consequently to more effective learning than the traditional approach. As a matter of fact, Physlets' interactivity feature facilitates students' active participation in classroom processes, which results in more intensive engagement with cognitive processes that are relevant for learning. Within the context of teaching about lenses, the benefit of using animations is related to the fact that one can easily trace a large number of rays that emanate from many different points of a bright object which is not easily done within the traditional approach. Changing the position of that object and visualizing how the change of position affects the propagation of light through the lens helps the learner to better understand the point-to-point correspondence between object and image, as well as the role of principal rays (Arons, 1997; Knight, 2004; Viennot, 2003). It seems that, within the context of teaching about lenses, printed sequences of static Physlets accompanied with corresponding worksheets have the potential to trigger similar cognitive processes as dynamic Physlets. Consequently, no statistically significant difference between the dynamic Physlets-approach and static Phylets-approach has been detected.

Generally, the level of effectiveness of a visualization is closely related to its potential to represent an anchoring context for triggering higher cognitive processes and fruitful classroom discussions (Mešić, Hajder, Neumann, & Erceg, 2016; Rapp & Curby, 2008). Our study shows that it is advisable to accompany instructional visualizations with explicit tasks that guide the learner through the process of qualitative and/or quantitative analysis of visual data.

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How Do Prospective Elementary and Gifted Education Teachers Perceive Scientists and Distinguish Science from Pseudoscience?

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Abstract

The present study aims to examine the perceptions towards scientists and science/pseudoscience distinctions of gifted education and elementary education teacher candidates who will educate gifted students especially at the elementary education level. A total of 92 volunteer prospective teachers, composed of candidates from gifted education and elementary education departments, participated in the study, which was carried out as a survey research. The data were collected using the Draw-a-Scientist Test and the Science/Pseudoscience Distinction Scale. The results of the study showed that both groups of prospective teachers' crafted drawings that reflected stereotypical perceptions in terms of appearance, work carried out by scientists, and gender. However, according to the results of the independent samples t-test, the elementary education teacher candidates were found to reflect more stereotypical characteristics in their drawings of scientists than the gifted education teacher candidates. The candidates' science/pseudoscience distinction scores did not significantly differ in department and there was a negative significant correlation between stereotypical image scores and scientific method scores.

Introduction

Today, the speed and ways of access to information is increasing. This process confronts us with many inventions and technologies that we have seen in science fiction films in the past and thought how they could be possible. While it is such a rapid process with many alternative ways to reach information, the extent to which the accessed information is scientific has become a situation which should definitely be considered. Because, today, when developments and applications such as the use of nanotechnology, the possibility of human cloning and migration to space are carried over to our daily lives, there are still also people who regulate their day or what they do or do not do according to astrological interpretations, rely on news about UFOs and reincarnation. That is why the production and use of scientific knowledge should be a responsibility not only to the scientists who have committed themselves to science but also to all the members of society. With this understanding, many countries have emphasized the importance of scientific literacy with educational reforms in order to enable the society to develop a correct and effective scientific understanding and apply it (Turgut, 2007). Therefore, in the current educational understanding, what is expected of people to do is not only to learn scientific facts, theories or laws but also to appreciate the value, power, characteristics and limits of scientific knowledge (Turgut, Akçay and İrez, 2010), and, at some point, to be able correctly grasp the nature of science.

Scientific literacy education is, especially, among the objectives to be achieved in science education in the Turkish system (MEB, 2013), but should not be limited to science education alone. In the education of scientifically literate individuals, whatever the sub-domain of science it is that is being taught, the essential point is that the nature of science should be grasped correctly (Lederman, 2007). The nature of science tries to explain what science is, how it works, how scientists work, how the society is guiding scientific knowledge and practices, and how the society reacts to these scientific applications (Ağlarcı and Kabapınar, 2016). One of the important characteristics of scientific literacy is to distinguish between science and pseudoscience as well as knowing the sub-dimensions of science and being scientific (Norris and Philips 2003; Lederman, 2007). The basic knowledge and perceptions about the nature and nature of science are dynamic, and their knowledge and perceptions change as they develop (Suchting, 1995).

In the process of separating the scientific from the non-scientific, it is necessary to define what science is. At this point, philosophers such as Popper, Kuhn and Feyeraband try to define science and make boundaires fot it but they differed on some issues like scientific process and validity criterions. These differentiations have become one of the major problem areas, especially since the early twentieth century, because they led to uncertainty about criterions on the separation of science from non-scientific areas (Mahner, 2007). It is still a matter of debate that there may be criteria for deciding what is scientific (Eş and Turgut, 2018). In this point, it is important that the demarcation of scientific and pseudoscientific knowledge is carried out; but an open, indisputable series of criteria that can be applied in any case for a definite demarcation has not yet been established (Turgut, 2011). However, it can be acted on some criteria suggested by different philosophical movements philosophers (Çetinkaya, Turgut and Duru, 2015). The falsifiability of scientific knowledge, its subjectivity, its inclusion of imagination and creativity for the benefit of people, its being a combination of observations and inferences, and its being influenced by social and cultural contexts can be regarded as the accepted criteria in assessing whether any emerging information is scientific or not (Lederman, 1999; Abd-El-Khalick and Lederman, 2000). In order for a solution to a problem to be scientific, it must be logical, correct, and depend on reliable observations and experiments. None of the forms of non-scientific solutions meet these three conditions. The disciplines that do not meet all of these conditions but bear one or two are defined as pseudoscience (Yıldırım, 2010). These disciplines are claimed to be scientific but are thoughts that cannot experimentally be tested (Preece and Baxter, 2000).

In order to overcome difficulties in demarcation, in Smith and Sharmann (1999)' approach, the question "What are the features that do or do not make a field more scientific ?" is seen as basic problem rather than the question of "Is this scientific or not ?" and a field revealed is judged by whether it is more scientific or less scientific. According to Smith and Sharmann (1999 the characteristics that make an field more scientific are "The object and Process of Study" and "Values of Science"; the characteristics that make a field less scientific are "Espousing a Theological Position", "Valuing Authority over Evidence "and" Fideism". When we look at the approaches in the literature, it can be said that this approach is better suited then giving certain lines for scientific or non-scientific (Eş and Turgut, 2018). Every day there are lots of news about information that is claimed to be scientific through the Internet, newspapers or televisions. Many individuals who cannot distinguish between science and pseudoscience easily make mistakes and suffer material and spiritual harm. For this reason, in particular, some criteria are needed to decide whether this information is scientific or pseudoscientific. Accordingly, as the number of scientifically literate individuals in the society increases, it will not be wrong to say that the views of the community towards science will improve (Driver et al., 1996).

One of the important influences in improving the scientific literacy levels of individuals in society is the proper settlement of perceptions about scientists, their characteristics, how they work and who can do science. The interest in and perceptions about science and scientists are very important in making scientific knowledge more accessible (Camci-Erdogan, 2018). Considering that the bases of the first science experiences of individuals are established in the elementary education, teachers' attitudes and the learning environment they prepare are influential on the interest, attitudes and performances of elementary school students towards science and scientists (Carnes 2009; Christidou 2011; She and Fisher, 2002; Sönmez, 2007, Washton, 1971). However, students who develop negative attitudes toward science and scientists do not see scientific subjects as interesting and do not want to choose a course or profession related to science in the future (Hammrich, 1997; Milford and Tippet, 2013).

Gifted students have an inherent interest in scientific subjects because such subjects nurture their instinctual curiosity and motivation (SmutnyVon and Fremd, 2004). They have the ability to transfer inferences from different events and situations to unusual situations in everyday life (Kopelman, Galasso and Strom, 1977; Ngoi and Vodracek, 2004). They achieve such inferences through scientific processes by closely observing their environments (Karnes and Riley, 2005), by recognizing and identifying the problems that others have missed (Meador, 2003), and by enjoying the exploration of open-ended problem situations. They have a passion including motivation, insistence, discovery skills and natural ability towards scientific subjects. It can be said that these students with characteristics such as being highly interested in exploring scientific events, being inclined to observe and ask questions, and having a deep interest in any discipline of science (Cooper, Baum and Neu, 2004, 2005; Taber, 2007) are the individuals who have a prominent role in the production of scientific knowledge or in its effective use. Accordingly, it would not be wrong to say that giving precedence to the education of gifted students is one of the most valuable investments that a society can make towards its future. Teachers who will educate gifted students should be at a level that can support and push forward such motivation, desires and interests of the students, because elementary teachers are one of the primary sources of information for science and scientists, and the influence they have on their students cannot be denied (Matthews and Davies, 1996; Christidou 2011; Moseley and Norris, 1999).

At the level of elementary education, students get introduced to subjects like science, scientific knowledge, and scientists in the formal sense or improve their knowledge on such knowledge areas with the help of their teachers (Turgut et al., 2016). In our current education system, a gifted student is educated at the elementary level either by an elementary teacher or by a gifted education teacher who has been appointed as an elementary teacher. At this point, the perception, attitudes and beliefs that the prospective teachers of elementary education and gifted education — who are more likely to work with gifted students in the first stages of elementary education —have towards science and scientists are very important.

It should be among the targets of teacher education institutions to know the views of prospective teachers who will educate future scientifically literate individuals about scientists and scientific/non-scientific activities and to try to overcome their misconceptions about these issues (Ağlarcı and Kabapınar, 2016). The reason is that teacher candidates' views on science and science subjects are based on their experiences in their own school years. Their views are very rooted and resistant to change (Hewson and Hewson, 1989). Since the study of Mead and Metraux (1957) on high school students' perceptions towards scientists, many studies have been carried out on different groups. Studies were carried out on such as elementary students (Buldu, 2006; Kaya, Doğan and Öcal, 2008; Türkmen, 2008), elementary and secondary students as a comparison (Akcay, 2011; Fung, 2002, secondary students (Camci, 2008; Gonsoulin 2001; Song and Kim, 1999), secondary gifted students (Camci-Erdogan, 2013a, 2013b; Kemaneci, 2012; Turgut, Öztürk and Eş, 2017). Based on these studies carried out with students it has been revealed that participants mostly have a stereotypical perception towards scientists whom they perceived as a middle-aged, lonely male wearing a laboratory coat and glasses and experimenting in a laboratory. Studies in the literature are mostly concerned with the students but also some studies conducted with the teacher candidates. These studies are mostly conducted with elementary teacher candidates (Çermik, 2013; Reap, Cavallo and McWhirter, 1994; Ünver, 2010), mixed groups (science, social studies, elementary, music etc.) (Bozdoğan, Şengül and Bozdoğan, 2013; Moseley and Norris, 1999; Özkan et al.,2017; Ürey et al., 2017). When looking at the results of available research, similar to the work done by the students in the studies conducted with the prospective teachers, it has been revealed that mostly the teacher candidates have stereotypical image of scientists as middle aged lonely men working with laboratory materials in a closed environment. As a result of these studies, stereotypes for scientists are formed at the level of elementary education and continue for many years or even for life. So it is important to determine image of elementary teachers of gifted students who have are thought to play an important role because of their potential. But researcher had reached only one study conducted with gifted education teacher candidates (Camci-Erdogan, 2018) who will give the initial guidance and effect in the academic and scientific life of gifted students.

Considering the studies focusing on the distinction between science and pseudoscience, many studies have been carried out on teacher candidates (Ağlarcı and Kabapınar, 2016; Ayvacı and Bağ, 2016; Berkant and Ermeydan, 2017; Çetinkaya, Laçin-Şimşek and Çalışkan, 2013; Kallery, 2001; Losh and Nzekwe, 2011; Saka and Sürmeli, 2017; Şenler and İrven, 2016; Turgut, 2009; Turgut et al., 2016; Yates and Chandler, 2000) and teachers (Berkman, Pacheco and Plutzer, 2008; Eve and Dunn, 1990; Nehm and Schonfeld, 2007). It is seen that in our country, Turkey, studies focusing on the distinction between science and pseudoscience mostly have included prospective science teachers (Ağlarcı and Kabapınar, 2016; Çetinkaya, Laçin-Şimşek and Çalışkan, 2013; Saka and Sürmeli, 2017; Turgut, 2009; Turgut, 2011; Turgut, Akçay and İrez, 2010) who are regarded as the most important and responsible individuals for raising scientifically literate individuals. The task prospective science teachers have in terms of raising scientifically literate individuals is obvious. However, in the framework of formal education — especially at the elementary education level — the first teachers the students will work with to study scientific literacy will be the elementary school teachers. The first teachers the gifted students will work with in the same manner will be the gifted education teachers. Gifted students share their first official science practice with elementary education and gifted education teachers. For this reason, the role of elementary and gifted education teachers is crucial as the first step in scientific literacy, scientific skills and in general science education (Akerson, Buzzelli & Donely, 2010). So the aim of the present study is therefore to determine the perceptions towards scientists and science/pseudoscience distinctions of gifted and elementary education teacher candidates who will give education to gifted students at the elementary level and guide them to the exploration, use and production of scientific knowledge. For this purpose, research problems are as follows:

1. What are images of scientists of candidate elementary education and candidate gifted education teachers according to departments?
2. Do teacher candidates differ in stereotypical image scores of scientists according to department?
3. Do teacher candidates differ in science/pseudoscience distinction scores according to department?
4. What are images of scientists of candidate elementary education and candidate gifted education teachers according to genders in department?
5. Do teacher candidates' stereotypical image mean scores differ according to gender in departments?
6. Do teacher candidates' science/pseudoscience distinction mean scores differ according to gender in departments?

7. Is there any correlation between stereotypical image scores and science/pseudoscience distinction scores?

Method

Design of the Study

This study was carried out as a survey research with the aim of determining science/pseudoscience distinction levels of prospective teachers of elementary and gifted education and their perceptions towards scientists.

Participants

The sample of the study consisted of 92 teacher candidates who were studying in 4th (last) grade of the Gifted Education and Elementary Education undergraduate departments at a state university located in Istanbul in the academic year of 2016–2017. The convenience sampling method, one of the purposive sampling methods (Creswell, 2012; Yıldırım and Şimşek, 2008), was adopted when determining the sample. The participant was given information about the subject of study by the researcher in separate groups as elementary and gifted education department. Participants voluntarily participated in the study. Seven students were excluded from the study because they did not have drawings for scientists and they responded some items multiple times on likert type scales. The department and gender distribution of the candidates participating in the study is given in Table 1. Table 1 shows that there were 43 (86%) female and 7 (14%) male participants from the elementary education department, and 30 (85.7%) female and 5 (14.3%) male participants from the gifted education department.

Table 1. Frequency and percentages according to department and gender

Department	Gender	f	%
Elementary Education	Male	7	14
	Female	43	86
	Total	50	100
Gifted Education	Male	5	14.3
	Female	30	85.7
	Total	35	100

Data Collection Tools

Draw-a-Scientist Test (DAST)

The Draw-a-Scientist Test (DAST) (Chambers, 1987) was used to determine the data for the perceptions towards the scientists in the study. This was a test that allowed people to draw pictures to explain their thoughts about scientists. In this test, the students were given the following instruction: “Please close your eyes and imagine a scientist working. Open your eyes and draw the scientist you imagined.” Underneath the blank area for drawing was a field for the students to mark the age and gender of the scientist. Drawing ideas and perceptions towards scientists is an advantage for DAST in terms of allowing participants to express their own ideas freely and to facilitate its implementation (Öcal, 2007).

Science/Pseudoscience Distinction Scale

The Science/Pseudoscience Distinction Scale was used in obtaining science and pseudoscience distinction scores of the teacher candidates. The original of the scale was developed by Oothoudt (2008) and adapted to Turkish by Çetinkaya, Laçin-Simşek and Çalışkan (2013). The scale consisting of 23 Likert-type items had four sub-dimensions as “Pseudoscience, Scientific Method, Science/Pseudoscience Distinction and Pseudoscientific Beliefs.” The Cronbach-alpha coefficient of the adapted scale had been found to be .75 as a result of the reliability analysis, while its Cronbach-alpha coefficient of scale was .73 and four sub-dimensions as Pseudoscience, Scientific Method, Science/Pseudoscience Distinction and Pseudoscientific Beliefs were successively .75, .71, .69 and .68 in the present study.

Data Collection and Analysis

The two scales were applied together to the volunteer teacher candidates. In the analysis of teacher candidates' drawings regarding scientists, the Draw-a-Scientist Checklist (DAST-C) developed by Finson, Beaver and Cramond (1995) was used. When the variables were coded, the expressions that reflected stereotypes in perception towards scientists were coded as 1, and their absence was coded as 0. The stereotypes towards scientists were coded as follows:

1. Laboratory Coat: In the drawings of teacher candidates, if the scientist wore a lab coat, this was coded 1. If the scientist was not wearing one, it was coded 0.
2. Glasses: This was coded 1, if the scientist was wearing eyeglasses. It was coded 0, if the scientist was not wearing them.
3. Beard/Mustache: If the scientist was wearing any combination of beard, mustache or sideburns, this was coded 1. If not, it was coded 0.
4. Messy-looking: If the scientist was messy-lookin, it was code 1. If not, it was code 0.
5. Research Symbols: If there was a beaker, volumetric flask, lame/lamella, solution, or any similar laboratory equipment in the drawings, this was coded 1. If there was no laboratory equipment, it was coded 0.
6. Information Symbols: If there were symbols in the drawings, such as a book, file, pen, or note, this was coded 1. If there were no symbols, it was coded 0.
7. Technology Symbols: The presence of any technological objects such as a television, telephone, robot, computer, microscope, or telescope was coded as 1. Their absence was coded as 0.
8. Gender: If the scientist was male, this was coded 1. If the scientist was female, it was coded 0.
9. Lonely Working: If the scientist was working alone, it was code 1. If not, it was coded 0.
10. Working Environment: If the scientist was working in a closed interior (such as a laboratory or library), this was coded 1. If the scientist was working outside, it was coded 0.
11. Age of the Scientist: If the scientist's age was expressed as 40 or more, this was coded 1. If it was expressed as 39 or below, it was coded 0.

The increase in the scores received by the prospective teachers indicates that they reflected more stereotypical characteristics in their drawings. In the study, two experienced experts evaluated 10% of the number of participants (10 participants) together during the evaluation of scientist drawings. Experts shared their decisions with each other after they have completed coding individually. Each of them declared their ideas on codes that are not consensus. They convince each other through this idea sharing and then they negotiated the codes on which they did not agree to come up with the final codes. The Science/Pseudoscience Distinction scale was applied in collectively to both groups and given as long as participants wished to participate. Since the collected data was likert type, it was coded 1 for "I strongly do not agree", 2 for "I do not agree", 3 for "I am undecided", 4 for "I agree" and 5 for "I strongly agree". Reverse encoded items are corrected. In addition, skewness and kurtosis coefficients were checked based on the analyses to examine whether the data were normally distributed. The skewness and kurtosis coefficients calculated for the stereotypical scientist perception score were .648 and .845, and for the Science/Pseudoscience Distinction score, .454 and .021, respectively. According to these results, frequency, percentage, independent samples t-test and correlational analysis were used in the analysis of the data showing normal distribution.

Results

1. What are images of scientists of candidate elementary education and candidate gifted education teachers according to departments?

Table 2 shows that almost half (44%) of the prospective elementary teachers described a scientist with a laboratory coat, while 14.3% of the prospective gifted education teachers described a scientist with a laboratory coat. Both elementary education and gifted education teacher candidates drew scientists with an almost 50% messy-looking image. 88% of elementary education teacher candidates portrayed the scientist with research symbols such as a beaker, volumetric flask and test tube, while 40% of prospective teachers of gifted education used these symbols. Symbols such as books and desktop notes were used at 50% level in both groups. While more than 50% of elementary education teacher candidates described the scientist as a male, more than 50% of the prospective teachers of gifted education described the scientist as a female. A great majority of both groups drew scientists as a person working alone (100% and 85.7%, respectively) indoor (90% and 74.3%, respectively). More than half of the teacher candidates in both groups portrayed that the scientist was 10 to 39 years old.

Table 2. Frequency and percentages of stereotypes according to department

	Elementary Education		Gifted Education	
Codes	f	%	f	%
Laboratory Coat	22	44	5	14.3
Glasses	20	40	8	22.9
Beard/Mustache:	6	12	2	5.7
Messy-looking	25	50	17	48.6
Research Symbols	44	88	14	40
Information Symbols	24	48	19	54.3
Technology Symbols	5	10	14	40
Male	30	60	13	37.1
Female*	19	38	19	54.3
Lonely Working	50	100	3	85.7
Working Inside	45	90	26	74.3
At the age of 40 and up	21	42	11	31.4

* Even though the code of female image was not on the markers as a stereotype, it was included in the table because it was an important finding for study.

Figure 1. Sample image belongs to a gifted education teacher candidate

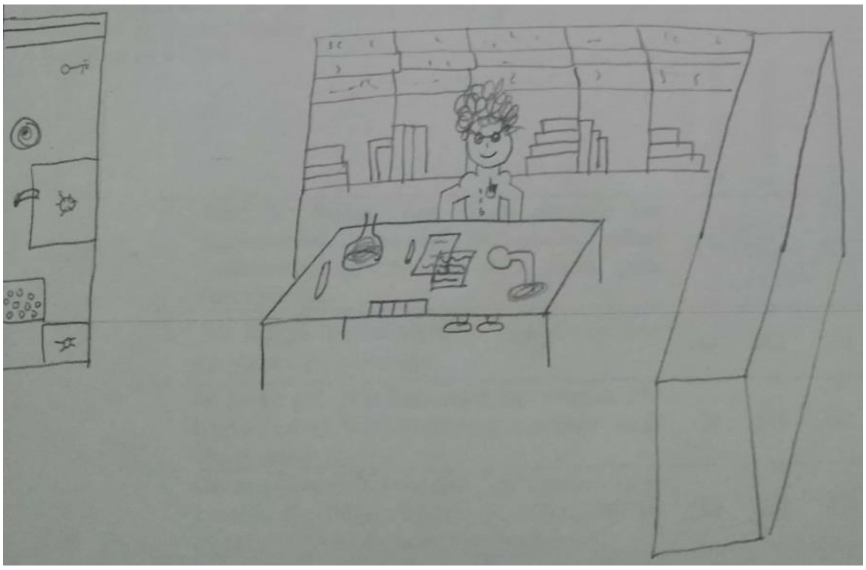

Figure 2. Sample image belongs to a elementary education teacher candidate

2. Do teacher candidates differ in stereotypical perception scores of scientists according to department?

Table 3 shows that the stereotypical perception scores of the prospective teachers had a statistically significant difference in terms of the department in which they studied (t=2.76, p<.05). At this point, it was revealed that the teacher candidates who were studying in the department of elementary education had more stereotypical images in terms of perception towards scientists than those who studied in the department of gifted education.

Table 3. Independent t test analysis for images: Department

	Department	N	Mean	Std. Deviation	t	df	p
Stereotypical perception scores	Elementary Education	50	6	2.109	2,76	83	.007*
	Gifted Education	35	4.69	2.223			

*p<0.05 There was a significant difference.

3. Do teacher candidates differ in science/pseudoscience distinction scores according to department?

Table 4 shows that the scores obtained from the science/pseudoscience distinction scale of the prospective teachers of elementary education and gifted education did not differ significantly based on their departments, neither in any of the sub-scales — specifically, pseudoscience (t=.201, p>.05), scientific method (t=-1.162, p>.05), science/pseudoscience distinction (t=1.318, p>.05), pseudoscientific beliefs (t=-.327, p>.05) — nor in the whole of the scale (t=.115, p>.05).

The mean scores of the teacher candidates taken from the sub-dimensions and the overall scale were evaluated according to their average weight values. The ranges in the 5-point Likert type scale were determined to be 1.0–1.8, 1.9–2.6, 2.7–3.4, 3.5–4.2 and 4.3–5.0 for "Very Low," "Low," "No Idea," "High" and "Very High," respectively (Ayvacı and Bağ, 2016). The average scores of the gifted education and elementary education teacher candidates show that both groups were in the level of "No idea" in terms of the pseudoscience and pseudoscientific beliefs sub-dimension. The scores of the groups in the scientific method and science/pseudo-science distinction sub-dimensions and in the whole scale were all "High."

Table 4. Independent t test analysis for science/pseudoscience distinction: Department

Science/pseudoscience distinction scale scores	Department	N	Mean	Std. Deviation	t	df	p
Pseudoscience	Elementary Education	50	3.04	.387	.210	90	.834
	Gifted Education	35	3.02	.508			
Scientific method	Elementary Education	50	3.93	.415	-1.162	90	.248
	Gifted Education	35	4.03	.332			
Science/pseudoscience distinction	Elementary Education	50	4.05	.465	1.318	90	.191
	Gifted Education	35	3.91	.539			
Pseudoscientific beliefs	Elementary Education	50	3.23	.608	-.327	90	.745
	Gifted Education	35	3.28	.798			
Whole of the scale	Elementary Education	50	3.60	.266	.115	90	.909
	Gifted Education	35	3.59	.303			

4. What are images of scientists of candidate elementary education and candidate gifted education teachers according to genders in department?

The percentages, frequencies and averages of scores were compared in gender comparisons rather than independent sample t test because of the difference in the distribution between male and female students.

Table 5. Frequency and percentages of stereotypes according to gender in departments

Codes	Gifted Education				Elementary Education			
	Male		Female		Male		Female	
	f	%	f	%	f	%	f	%
Laboratory Coat	1	20	4	13.3	1	14.3	21	48.8
Glasses	2	40	6	20	3	42.9	17	39.5
Beard/Mustache	0	0	2	6.7	1	14.3	5	11.6
Messy-looking	4	80	13	43.3	5	71.4	20	46.5
Research Symbols	2	40	12	40	3	42.9	41	95.3
Information Symbols	3	60	16	53.3	1	14.3	23	53.5
Technology Symbols	2	40	12	40	2	28.6	3	7
Male	4	80	9	30	7	100	23	53.5
Female*	1	20	18	60	0	0	19	44.2
Lonely Working	5	100	25	83.3	7	100	43	100
Working Inside	5	100	21	70	4	57.1	41	95.3
At the age of 40 and up	3	60	8	26.7	5	71.4	16	37.2

* Even though the code of female image was not on the markers as a stereotype, it was included in the table because it was an important finding for study.

Table 5 shows that the female teacher candidates in elementary education department drew the scientists with laboratory coat (48.8%) and glasses (39.5%) with a higher percentage than the female candidates of gifted education department (13.3%; 20%, respectively). Almost all female elementary teacher candidates used research symbols in their drawings (95.3%), while less than half of the female gifted teacher candidates (40%) used research symbols in their drawings. From the point of view of the use of the technology symbols, it was seen that female gifted education teacher candidates reflected higher percentage than female elementary education teacher candidates.

While almost all of male teacher candidates in both groups drew male scientist, the situation in female teacher candidates is different. While 30% of the female gifted education teacher candidates drew male scientists, 60% of them drew female scientists. And 53.3% of the female elementary teacher candidates drew male scientists, 44.2% of them drew female scientists. Teacher candidates in both groups have dreamed and drew scientists working alone and indoors at high percentages. When we look at the age of the drawn scientists, it has been seen that female gifted teacher candidates have drawn scientists over 40 years with a lower percentage than female elementary teacher candidates. In other words, female gifted education teacher candidates tend to imagine scientists to be under 40 years old.

5. Do teacher candidates' stereotypical perception mean scores differ according to gender in departments?

Table 6 shows the results of the descriptive analysis in order to see the difference difference between the scores of stereotypical perceptions towards scientists according to the gender of candidates in departments.

Table 6. Descriptive values of stereotypical perception scores due to gender in departments

	Department	Gender	N	Min	Max	Mean	Std. Deviation
Stereo typical perception scores	Gifted Education	Male	5	4	10	6.40	2.510
		Female	30	0	10	4.40	2.094
	Elementary Education	Male	7	4	8	5.57	1.813
		Female	43	3	13	6.07	2.165

The low level of stereotypical perception scores is interpreted as the fact that teacher candidates reflect less stereotypical images of scientists. In this context Table 6 shows that the average stereotypical perception scores of female gifted eduction teacher candidates (x̄=4.40) was lower than the average stereotypical perception scores of female elementary education teacher candidates (x̄=6.07). From the point of view of male candidates, it is seen that the average scores of elementary teacher candidates (x̄=5.57) are lower than those of gifted education teacher candidates (x̄=6.40).

6. Do teacher candidates' science/pseudoscience distinction mean scores differ according to gender in departments?

Table 7 shows the descriptive values of science/pseudoscience distinction scores and the mean scores of the teacher candidates taken from the sub-dimensions and the overall scale were evaluated according to their average weight values. The ranges in the 5-point Likert type scale were determined to be 1.0–1.8, 1.9–2.6, 2.7–3.4, 3.5–4.2 and 4.3–5.0 for "Very Low," "Low," "No Idea," "High" and "Very High," respectively (Ayvacı and Bağ, 2016). The average scores of the gifted education and elementary education teacher candidates show that all groups were in the level of "No idea" in terms of the pseudoscience sub-dimension. Male gifted education teacher candidates were at "High level" while all the other groups were in the level of "No idea" in terms of pseudoscientific beliefs sub-dimension. The scores of the groups in the scientific method and science/pseudo-science distinction sub-dimensions and in the whole scale were all "High."

Table 7. Descriptive variables of science/pseudoscience distinction scores due to gender in departments

Department	Gender	Scale	N	Min	Max	Mean	Std. Deviation
Gifted Education	Male	Pseudoscience	5	2	4	3.11	.814
		Scientific method	5	4	5	4.29	.286
		Science/pseudoscience distinction	5	3	4	3.77	.560
		Pseudoscientific beliefs	5	2	5	3.60	1.01
		Whole of the scale	5	3	4	3.70	.219
	Female	Pseudoscience	30	2	5	3.00	.458
		Scientific method	30	3	5	3.99	.323
		Science/pseudoscience distinction	30	3	5	3.93	.541
		Pseudoscientific beliefs	30	2	5	3.22	.765
		Whole of the scale	30	3	4	3.57	.314
Elementary Education	Male	Pseudoscience	7	3	3	2.87	.212
		Scientific method	7	3	4	4.04	.486
		Science/pseudoscience distinction	7	4	5	4.07	.286
		Pseudoscientific beliefs	7	2	4	3.10	.630
		Whole of the scale	7	3	4	3.57	.189
	Female	Pseudoscience	43	2	4	3.07	.402
		Scientific method	43	3	5	3.92	.428
		Science/pseudoscience distinction	43	3	5	4.04	.498
		Pseudoscientific beliefs	43	2	5	3.25	.600
		Whole of the scale	43	3	4	3.61	.287

7. Is there any correlation between stereotypical image scores and science/pseudoscience distinction scores?

Table 8 shows, there was a negative significant correlation between stereotypical image scores and scientific method scores [r(85)=.-.221; p<.05). That means stereotypical image score increases while the scientific method score decreases. As the image of the scientist is stereotyped, the individual move away from the scientific method.

Table 8. Correlation values between stereotypical image scores and science/pseudoscience distinction scores

	Whole of the scale	Pseudoscience	Scientific method	Science/pseudoscience distinction	Pseudoscientific beliefs
Stereotypical image score	-.154	-.081	-.221*	-.074	-.036

*Correlation was significant at the .05 level.

Discussion and Conclusion

Based on the image of scientists and the level of science/pseudoscience distinction levels of prospective teachers of gifted education and elementary education, it was revealed that the prospective teachers reflected stereotypical perceptions towards scientists in their drawings in general. In the same way as many studies in the literature (Bozdoğan, Şengül and Bozdoğan, 2013; Camci-Erdogan, 2018; Çermik, 2013; Moseley and Norris, 1999; Özkan et al. 2017; Reap, Cavallo and McWhirter, 1994; Şenel and Aslan, 2014; Ünver, 2010; Ürey et al. 2017) the teacher candidates of both gifted education and elementary education portrayed scientists mainly as a middle-aged, messy-looking person wearing a laboratory coat and glasses and working alone on chemicals in the laboratory. As a result of comparison between the two groups based on the stereotypical images in the drawings of scientists, it was revealed that the teacher candidates of elementary education had more stereotypical image and perception for scientists. This may had been due to the fact that the gifted education students had to take very different courses in the teacher education program, differently from the elementary education program, and in these courses they had seen different scientists (difference in gender, age, ethnicity etc.) and different ways of thinking. It may be effective, however, to take a number of lessons on the creation and development of scientific knowledge and scientific method and to participate in different projects supported at the national level in order to guide the gifted students on their curiosity about science and scientific method. It would not be wrong to say that the teacher candidates' drawings are rooted in the belief that it is exhausting and backbreaking to do science based on the presence of messy-looking scientists wearing glasses (Camci-Erdogan, 2018; Ünver, 2010; Yontar-Toğrol, 2000). Nevertheless, it is necessary to keep in mind that doing science is perceived as working in the laboratory alone, in isolation from society, based on the drawings portraying scientists working behind closed doors alone. Similar results have been found in previous studies and it has been emphasized that the figures of scientists used in textbooks in the Internet, visual and printed media seriously affect the formation of these images (Camci-Erdogan, 2013a, 2013b; Camci-Erdogan, 2018; Schibeci, 1986; Song and Kim, 1999; Yontar-Toğrol, 2000).

When the teacher candidates' drawings of scientists are considered in terms of what scientists do, it turns out that a great majority of the prospective teachers of both groups bu especially female elementary teacher candidates (95.3%) reflect scientists only as someone experimenting with chemicals in the laboratory. This leads students to not see alternatives in terms of scientific literacy with regard to how scientific knowledge is produced, ways of reaching scientific knowledge, and how scientists work, which limits the perception about scientific knowledge only to sciences.

One of the most important stereotypes for the perception towards the scientist is imaging a man. In almost all of the studies on the topic, a large part of students or teacher candidates have described the scientists as males (Buldu, 2006; Camci-Erdogan, 2013a, 2013b; Chambers, 1983; Çermik, 2013; Flick, Fort and Varney, 1989; Fung, 2002; Gonsoulin, 2001; Kaya, Doğan and Öcal, 2008; Kemaneci, 2012; Mead and Metraux, 1957; Narayan et al., 2007; Schibeci, 2006; Song and Kim, 1999; Symington and Spurling, 1990; Türkmen, 2008; Ünver, 2010; Yontar-Toğrol, 2000). In the present study, while the vast majority of the prospective female elementary education teachers drew male scientists, the majority of the prospective female gifted education teachers drew female scientists. This is particularly promising in terms of breaking the notion that doing science is specific to men, and in establishing the idea that there are and will be female scientists in all areas of science (especially in physical sciences). In particular, female gifted students have a great need for their skills to be supported by role models in terms of expressing themselves on scientific platforms and not concealing themselves (Camci-Erdogan, 2013a; Camci-Erdogan and Riga, 2016). Because gifted girls mask their potential in scientific issues and it is known as an important problem on the field (Camci-Erdogan, 2013a), Therefore, it is very important for the teacher to convey to students the perception that science can be done at an equal level in terms of both genders in society. And gifted education candidates sholud have knowledge at the point of showing correct role models to girls in scientific fields.

When we look at the age range chosen by the prospective teachers of both gifted education and elementary education to portray a scientist in their drawings, about age, both groups portrayed scientists at 30–40 age range. It cannot be denied that science is still influenced by printed media, visual media and Internet tools in terms of confining science to an age level, which can be considered a middle age in general. At this point, it can be said that, in terms of scientific literacy, we lack the emphasis that science is for all ages, and that science can be done by everyone from birth to death. The fact that scientists were working in isolation from the society in the drawings of prospective teachers confirms the perception that science cannot be done by anyone, but only by certain people. Therefore, to properly structure scientific literacy, it must be emphasized that science can be understood and done by all.

Considering the science/pseudoscience distinction scores of both groups, it was seen that prospective teachers were undecided or had no opinion on the expressions in the sub-dimension of the pseudoscience and pseudoscientific beliefs. However, it was revealed that scores of both groups were high in the scientific method, science/pseudoscience sub-dimensions and in the whole of the scale. Teacher candidates made more precise, clear and accurate decisions on issues such as scientific method and scientific research. Candidates were undecided about the pseudoscience-related issues (e.g., “Houses are visited by the ghosts of the deceased people.”) and expressed their lack of ideas. However, it is also evident that the scientific method subscale is correlated reversely to the stereotypes about scientists. At this point, it has emerged that prospective teachers who have mastered the scientific method process have less stereotypes for scientists. People believe in pseudoscientific explanations because pseudoscientific explanations are given scientific implications (Yıldırım, 2008) and pseudoscientific explanations are easier to understand than scientific explanations (Lindeman, 1998). However, the individual who knows the formation and characteristics of scientific knowledge can distinguish and put into practice scientific thought from pseudoscientific thought (Lederman, 2007). Teacher candidates familiarize with content related to scientific methods that they receive in the Scientific Research Method course and in other courses. It can be said that such contents are effective in teaching them to make more accurate and clear decisions about scientific methods. At this point, it is understood that it is necessary to offer courses with content focusing on the nature of science and what characteristics should be considered in distinguishing scientific explanations from pseudoscientific explanations, as well as emphasizing the importance of assessing the source of information.

It is very important to make the right beginnings in the learning process, because it is difficult to change the incorrect understandings, prejudices or stereotypes. Studies conducted with gifted students show that these students are thought to be reached scientific evidence through empirical evidence, they are largely focused on the scientific process and in this context they are more likely to portray male scientists using glasses and laboratory coats using experiment apparatus (Camci-Erdogan, 2013a, 2013b; Turgut, Öztürk and Eş, 2017). In this context, it is necessary that the teachers who work/will work at the elementary school level should be the right role models in terms of perception towards science by the learners and guiding this perception. Because, knowledge, attitudes and values possessed by the learners towards science and scientists are influenced by the knowledge, attitudes and values of their teachers (Altınok, 2004; Palmer, 2001). At this point, being a role model is more important for the teachers — who will work with gifted students who are instinctively curious and motivated to study science and explore — to advance such students’ current performance further, to the level of enjoying science. It is essential that teachers whether they work with students who are diagnosed as gifted or not are educated as individuals who are open-minded, inquiry-minded, critical and creative, away from stereotypical thoughts. Therefore, it is necessary for the prospective teachers to directly take courses related to science (such as philosophy of science and history of science) during the undergraduate education. In addition, it is necessary to include critical, creative and evaluative thinking processes about how to distinguish scientific knowledge from pseudoscientific knowledge and how to obtain accurate and reliable scientific resources in the context of these courses. These contents should not only be in a theoretical structure, but also create practical environments where students can criticize scientific knowledge, its source and its presentation and give them opportunity to contemplate the subject and reflect it in the daily life. Teacher candidates must be confronted with the perception towards the scientists they possess and should be heading for thinking about this perception. They should be introduced to the right role models working in different areas of science and be shown that science is in fact very close, that it is not and cannot be isolated from society.

Recommendations

The present study was carried out as a survey research to determine the perceptions towards scientists and science/pseudoscience distinctions of prospective teachers of gifted education and elementary education who are likely to be teaching to gifted students. It can be suggested for future studies that this study is supported by interviews with teacher candidates in terms of both perception towards scientists and decisions regarding the science/pseudoscience distinction, with the hope that the interviews will further the present study.

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Correlation between Understanding about Nature of Science and Orientation to Teaching Science: An Exploratory Study with Thai First-Year Preservice Biology Teachers

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Abstract

Research in teacher education has given increasing attention to pedagogical content knowledge (PCK) as a theoretical construct that describes necessary knowledge for teachers to teach specific content. This research study aims to examine whether an understanding about the nature of science (NOS) correlates with orientation to teaching science (OTS), which is an overarching component of PCK for teaching science. Nineteen first-year preservice biology teachers completed adapted versions of an open-ended questionnaire called V-NOS and a multiple-choice OTS test called POSST whose data were transformed and then analyzed using Pearson's correlation. The results reveal a slightly negative correlation between these two variables, which is not statistically significant ($r = -.227$, $p = .351$). This result suggests that understanding of the NOS may not be a dimension of OTSs, so facilitating understanding of the NOS may not necessarily lead to inquiry-based OTSs.

Introduction

Since Shulman (1986) introduced a theoretical construct called pedagogical content knowledge (PCK) to describe necessary knowledge for teaching specific content, this construct has been elaborated further to guide science teacher education and research (Abell, 2008). Magnusson, Krajcik, & Borko (1999), for example, identify five components of PCK for teaching science, which include (a) orientations toward teaching science (OTSs), (b) knowledge and beliefs of science curricula, (c) knowledge and beliefs of students' understanding of science, (d) knowledge and beliefs of assessment of scientific literacy and (e) knowledge and beliefs of instructional strategies. The first component is defined as "knowledge and beliefs about the purposes and goals for teaching science" (p. 97), which overarches and interacts with the other four components when science teachers develop and use PCK. OTSs can serve as a filter for science teachers learning to teach specific content of science (Avraamidou 2013) and as a lens to understand science teachers' classroom practices (Boesdorfer & Lorsbach, 2014).

Despite its influential roles, OTSs are often taken for granted in the PCK research movement. A critical review by Friedrichsen, van Driel, & Abell (2011) revealed that OTSs are used in different or unclear ways with unclear or absent relationships with the other components. As a result, their nature becomes an issue in many ways. First, as Veal & Makinster (1999) suggest three levels of PCK (i.e., general PCK, domain-specific PCK, and topic-specific PCK), it is not clear whether OTSs are general or domain/topic-specific. Second, as Friedrichsen & Dana (2005) found, beliefs about students can serve as a source of OTSs, so it is not clear whether OTSs would vary according to students' grade levels with different educational purposes. Third, there is a lack of agreement on whether views of science should be a dimension of OTSs (Friedrichsen et al., 2011; Kind, 2016). One agreement seems to be that contexts where science teachers work can influence their OTSs (Friedrichsen & Dana, 2005; Ramnarain & Schuster, 2014; Ramnarain, Nampota, & Schuster, 2016) or at least influence the translation of their OTSs into classroom practices (Nargund-Joshi, Park Rogers, & Akerson, 2011). Hence, as Abell (2008) argued, OTSs deserve more attention in the research if this construct is to be useful in guiding science teacher education.

Whereas previous studies have focused on exploring OTSs held by experienced science teachers (e.g., Boesdorfer & Lorsbach, 2014; Faikhamta, 2013; Friedrichsen & Dana, 2005; Nargund-Joshi et al., 2011; Park & Chen, 2012; Ramnarain & Schuster, 2014; Ramnarain et al., 2016) or preservice science teachers with a few years in university (e.g., Avraamidou, 2013; Brown, Friedrichsen, & Abell, 2013; Demirdogen, 2016; Eick & Reed, 2002; Kind, 2016), a few studies, if any, have investigated OTSs held by first-year preservice science teachers who just entered science teacher education. Given that preservice science teachers have developed conceptions of teaching and learning, a dimension of OTSs according to Friedrichsen et al. (2011), since they were students (Lortie, 1975), a lack of research in this area with freshmen preservice science teachers becomes a shortcoming because their initial OTSs can play significant roles when engaging in science teacher education activities and coursework. Better understanding of their initial OTSs can help inform how science teacher education can be designed to facilitate their development of OTSs and PCK.

Theoretical Framework

More than 30 years ago, Shulman (1986) had introduced PCK as a theoretical construct to describe a unique kind of knowledge for teaching specific content. This kind of knowledge "goes beyond knowledge of subject matter per se" (p. 9) as teachers must also know how to pedagogically make such content or subject matter accessible and understandable to students with different abilities and backgrounds (Shulman, 1987). It is this special kind of knowledge that distinguishes teachers from content specialists. After its introduction, PCK has gained much attention because it aligns well with the current change in the educational paradigm which has undergone a shift from behaviorism with the emphasis on teachers' behaviors to constructivism with the emphasis on teachers' knowledge, beliefs and learning to teach (Richardson, 1991). Consequently, research on science teacher education has become devoted to developing science teachers' PCK in the various topics of science (van Driel, Verloop, & de Vos, 1998).

In this movement, Magnusson et al. (1999) has proposed a model of PCK for teaching science, which includes five components, as previously mentioned. OTSs are the overarching component that plays influential roles as they interact with the other four components. They also provide a list of nine different OTSs as found in the literature (i.e., process, academic rigor, didactic, conceptual change, activity-driven, discovery, project-based science, inquiry and guided inquiry). However, Friedrichsen et al. (2011) argued that some of these OTSs may overlap each other and that they may not be empirically supported by research with science teachers. Instead, they tend to represent OTSs as reflected in recommended instructional approaches of science curriculum development projects or contemporary reform-based projects. Therefore, to ensure empirically supported OTSs, Kind (2016) explored OTSs held by preservice science teachers by which she confirmed five OTSs (i.e., didactic, academic rigor, activity-driven, conceptual change and inquiry). In Thailand, which is the context of the present study, Faikhamta (2013) found five OTSs held by in-service science teachers (i.e., project-based science, process, guided inquiry, activity-driven and discovery).

Nonetheless, Friedrichsen et al. (2011) argued that a science teacher's OTSs can be complex and messy to be assigned as one specific type, and that he or she may simultaneously have more than one OTSs. In such cases, some of them are central, while the others are peripheral (Friedrichsen & Dana, 2005). Thus, researchers are cautioned not to identify one OTS for a science teacher too early. However, as an analysis of a science teacher's OTSs can be a time- and effort-consuming process (Friedrichsen & Dana, 2003), OTSs can be formatively assessed and then be used to inform a science teacher education program. Cobern et al. (2014) have developed a case-based assessment called a Pedagogy of Science Teaching Test (POSTT) to identify four common OTSs associated with the current science education reform. Those four OTSs can be viewed as a spectrum of two variants of direct instruction (i.e., didactic direct and active direct) and two variants of inquiry (i.e., guided inquiry and open inquiry). The two variants of direct instruction share a fundamental epistemic mode of ready-made science while the two variants of inquiry reflect that of science-in-the-making. On the side of direct instruction, didactic direct reflects a passive mode in nature, while active direct reflects a more hands-on or activity-based one. On the side of inquiry, the difference between the two is the extent of science teachers' scaffolding and students' independence in doing scientific investigation.

While the nature and types of OTSs can be issues, research consistently establishes that OTSs not only influence how science teachers decide to teach science (Boesdorfer & Lorsbach, 2014) but also how they develop PCK (Brown et al. 2013). For example, Park & Chen (2012) found that a didactic OTS held by a science teacher can direct his or her knowledge of instructional strategies, and that such connection can inhibit connections with other PCK components. In opposition, Eick & Reed (2002) found that preservice science teachers with a strong inquiry OTS not only benefit from supporting experiences in science teacher education with an emphasis on inquiry-based instruction, but also more easily put their facilitating roles into action when they support students' scientific inquiries. Given the significance of OTSs, science teacher education programs should facilitate preservice science teachers having inquiry-based OTSs as early as possible so that they can further facilitate the development of PCK. Certain experiences can potentially shape preservice science teachers' OTSs toward inquiry such as inquiry-based investigations, contemporary theoretical discussions, outdoor field study, friendly classroom environments and characteristics of the instructors (Avraamidou, 2013).

While inquiry-based OTSs can be facilitated during science teacher education programs, research also suggests that the contexts in which science teachers work can influence their OTSs (Friedrichsen & Dana, 2005). Using Cobern et al.'s (2014) POSTT, Ramnarain & Schuster (2014) compared OTSs held by two groups of science teachers working in different school contexts in South Africa. They found that science teachers at disadvantaged township schools tend to have a strong 'active direct' OTS while those at suburban schools tend to exhibit a 'guided inquiry' OTS. Similar results were found in their comparative study in South Africa and Malawi, showing that science teachers at more privileged schools show stronger guided- and open-inquiry OTSs than those at less privileged schools (Ramnarain et al., 2016). Such difference in OTSs may result from contextual factors in schools such as class size, availability of resources, time constraints, student ability, school culture and parents' expectations (Ramnarain & Schuster, 2014). Nargund-Joshi et al. (2011) also found that science teachers with a reform-based OTS can encounter difficulties in putting it in classroom practice due to contextual constraints such as large classes, limited time and a strong emphasis on external examination. It is likely that such experienced difficulties may in turn undermine their reform-based OTS towards a more didactic one.

As previously mentioned, there are some issues about the nature of the OTSs in the literature. In the present study, the focus is on one issue—that is, whether OTSs correlate with a view or understanding of the NOS, which can be explained by some key aspects such as scientific knowledge is empirically based, partially subjective and subject to change (Lederman, 1992). This issue came into being as Friedrichsen et al. (2011) proposed that the view of science may be a dimension of OTSs. This proposal aligns with some research findings showing interrelation between science teachers' beliefs of teaching, learning and science (e.g., Tsai, 2002). A relationship between reform-based OTSs and informed understanding of the NOS can be expected given the fact that they both reflect an epistemology of science-in-the-making. Moreover, as research suggests that inquiry-based instruction can both facilitate inquiry-based OTSs (Avraamidou, 2013; Britner & Finson, 2005) and be a context for explicitly addressing NOS aspects (Abd-El-Khalick & Lederman, 2000), it is reasonable to expect that OTSs and the NOS can be facilitated simultaneously with appropriate scaffoldings. However, Kind (2016) found that this may not be the case. Rather than being a dimension of OTSs, NOS should be "considered to be subject-specific content" (Faikhamta 2013, p. 850), not even taking part in Magnusson et al.'s (1999) model of PCK. It is this issue that the present study was designed to address.

Research questions

This research study aims to make the issue regarding the nature of OTSs clearer. It aims to address two research questions as follows:

1. What are first-year preservice biology teachers' OTSs?
2. Do first-year preservice biology teachers' OTSs correlate to their understanding about nature of science (NOS)?

Research methods

Context

This study took place in a university in the northern region of Thailand whose science education program is quite unique. It is locally called a 5-year parallel program in the sense that preservice science teachers study simultaneously in two curricula collaboratively developed by two faculties (i.e., School of Science and School of Education). Once they complete the requirements of these curricula, they receive two bachelor's degrees, both in Science and in Education. In this, preservice science teachers must study several science courses as well as educational courses as required by the Teachers' Council of Thailand before they receive a professional license and are qualified to teach in government or private schools.

Participants

Participants in this study were 19 first-year preservice biology teachers who are engaged in the 5-year parallel program. The participants included 5 males and 14 females with GPA ranging between 2.02 and 3.39 (M = 2.61, SD = 0.40). All the participants were purposively selected for convenient reasons as they had enrolled in a course called Self-Actualization for Professional Teachers, which aims to introduce them to their future roles and duties as science teachers as well as the laws and rules for teachers. Before this course, they had finished only one educational course, which was Educational Philosophy, since it was their second semester in the program during the study. They had passed neither any course on the NOS nor any course on the inquiry-based method.

Instruments

Orientation to teaching science

An instrument called POSTT (Cobern et al., 2014) was adapted and then used to gather data about the participants' OTSs. It was a case-based assessment in that the participants were presented with instructional scenarios in which they were asked to make decisions for action. For example, a scenario would be that a science teacher was teaching frog dissection. Then, the question that would be asked was, if the participants were in that teacher's place, what kind of action they would take to facilitate students' learning. In this assignment, the participants had four choices from which to select. Each choice corresponded to one in the spectrum of OTSs (i.e., didactic direct, active direct, guided inquiry and open inquiry), so it was possible to transform the participants' OTSs into quantitative data. Figure 1 illustrates one item of the POSTT.

Mr. Goodchild is doing a frog dissection with his 10^{th} graders to help teach about anatomy.
Thinking about how you would teach a lesson, of the following, which is most similar to what you believe is the best way to incorporate a dissection into a lesson?

A. It should be used as a stand-alone step-by-step activity for students to explore the frog's anatomy and raise discussion questions on their own. [Open inquiry]
B. It should be used as a follow-up step-by-step student activity after Mr. Goodchild explains exactly what students will need to notice about the frog anatomy. [Active direct]
C. It should be used as a step-by-step student activity while answering probing questions, followed up by teacher-led discussion and clarifications. [Guided inquiry]
D. It should be used as a step-by-step demonstration by Mr. Goodchild while he explicitly points out what students need to know about frog anatomy. [Didactic direct]

Figure 1. An example of the POSTT item (Cobern et al., 2014).

There were 16 items of the POSTT, and these items cover a number of science topics. According to Thailand's National Core Science Curriculum Standards (Bureau of Academic Affairs and Educational Standards 2010), students in basic education must learn science in eight strands, which include (1) living things and processes of life, (2) life and the environment, (3) substances and properties of substances, (4) force and motion, (5) energy, (6) change processes of the earth, (7) astronomy and space, and (8) nature of science and technology. Except for the last one, these strands can be categorized into three groups (i.e., biological sciences for the first two strands, physical sciences for the following three strands, and astronomical and earth sciences for the last two strands). There were five items for biological science, six for physical sciences, and five for astronomical and earth sciences. While the original POSTT does indicate students' educational levels in its scenarios, which may be different from what are specified in Thailand's National Core Science Curriculum Standards, the students' educational levels in the scenarios were adapted in order to be consistent with the context of the study. Table 1 shows the structure of the POSTT as used in the study.

The POSTT was translated from English into Thai and reviewed back and forth to ensure that its essential meanings were intact. Also, the original and the translated POSTT were sent to two science education researchers to check the translations, and they were improved according to the feedback and comments of the researchers. Once the translation was up to the satisfactory level, the translated POSTT was tried out with eight preservice science teachers who had studied in a nearby university. In doing so, a blank space was provided for those preservice science teachers to write their reasons so that it could be checked if their answers were consistent or contradicted with the reasons they provided, signaling their interpretation of each item. Feedback from this try-out led to the improvement of the POSTT to be used in the study.

Table 1. Structure of POSTT instruments.

Item	Content			Students' educational level		
	Biological	Physical	Astronomical and Earth	Lower Primary	Higher Primary	Secondary
1	✓					✓
2	✓					✓
3			✓		✓	
4		✓			✓	
5		✓			✓	
6			✓		✓	
7	✓			✓		
8	✓				✓	
9	✓					✓
10			✓			✓
11			✓	✓		
12		✓		✓		
13		✓				✓
14		✓			✓	
15		✓		✓		
16			✓			✓
Sum	5	6	5	4	6	6

Understanding of NOS

Views of Nature of Science Questionnaire (VNOS, Lederman et al., 2002) was adapted to elicit the participants' understanding of the NOS. It is an open-ended questionnaire, which consists of seven items, asking the participants to write their responses regarding the six aspects of the NOS: (1) that scientific knowledge has basis in empirical evidence (empirical NOS), (2) that scientific knowledge involves making inference based on evidences (inferential NOS), (3) that scientific knowledge is influenced and driven by scientists' personal subjectivity (subjective NOS), (4) that scientific knowledge is the product of human creativity and imagination (creative and imaginative NOS), (5) that scientific knowledge is subject to change (tentative NOS) and (6) that science is a human enterprise embedded in the practices of the society and culture (sociocultural NOS). Most of the items are context-free (e.g., 'What is science?', 'What makes science different from other disciplines?', 'Does scientific knowledge ever change?' and 'Do scientists use their creativity and imagination during their investigation?'). Some of the items, however, are contextualized to help the participants express their understanding of some aspects (e.g., 'How do scientists know about the characteristics of dinosaurs which became extinct million years ago?' and 'How are scientists sure about weather conditions as predicted by computer simulation?'). Similar to the POSTT, the VNOS was translated from English into Thai and reviewed back and forth to ensure that its essential meanings were not missed. Then, the original and the translated VNOS were sent to the same science education researchers to check the translations, and they were improved according to the researchers' feedback and comments until the translation was up to the satisfactory level. The translated VNOS was also tried with secondary students.

Data collection

Data collection was carried out the first time the participants attended the class. During the data collection, they were asked to complete the modified POSTT; they were encouraged by the fact that its results will expose their preference with regard to some specific ways of teaching science. They were also informed that there were no right or wrong answers for this measurement and that its results will not affect their grade of the course being studied. They were also advised that in cases where the given choices do not totally reflect their instructional preference, they could choose the one best aligned with their preference. They were also encouraged to provide reasons supporting their answers in all items so that it would be possible to examine whether they understood the items and whether there was any inconsistency between the chosen answers and the written reasons. The participants took approximately one and a half hours to complete the modified POSTT. A week later, the participants were asked to complete an adapted VNOS with a similar administration. In the assignment, they were encouraged to write with details and examples that illustrate their understanding of science. They were also informed that their responses were not evaluated as right or wrong, but were considered as showing how they viewed science as a discipline that they would be teaching in future. They took about 45 min to complete the questionnaire.

Data analysis

Data analysis for the modified POSTT was based on a scoring system in which 1 point was given for each answer representing a didactic-direct OTS, 2 points for an active-direct OTS, 3 points for a guided-inquiry OTS and 4 points for an open-inquiry OTS as an increase in the number of points reflects an instructional tendency that is more inclined towards scientific inquiry. As a result, each participant can possibly have a total score in the range of 16–64 points. This scoring system allowed the researchers to determine each participant's mean score (M) and standard deviation (SD). On using the Shapiro–Wilk test (Morgan et al., 2013), it was found that the OTS data were normally distributed at .05 ($W = .941$, $p = .277$) with an average score at 2.37 ($SD = 0.34$), suggesting that the participants tended to have OTSs between 'active direct' (2) and 'guided inquiry' (3). However, as shown in Table 2, four participants had average scores lower than 2.00, reflecting the didactic nature of their OTSs.

Table 2. Participants' OTS scores on modified POSST OTSs.

No.	Item																M	SD
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
1	1	1	4	4	1	4	1	2	4	1	4	2	4	1	4	4	2.63	1.45
2	4	4	1	4	4	4	3	1	4	1	4	2	1	4	1	4	2.88	1.41
3	1	3	1	4	3	3	4	2	3	3	4	2	2	3	3	4	2.81	0.98
4	1	3	1	1	2	4	3	2	3	3	2	2	1	4	4	1	2.31	1.14
5	2	1	4	3	1	2	1	2	2	1	2	2	1	1	4	1	1.88	1.02
6	3	4	2	4	2	2	3	2	3	3	3	3	3	1	3	1	2.63	0.89
7	1	1	2	1	2	3	3	1	1	4	1	2	4	3	3	3	2.19	1.11
8	2	1	1	2	1	4	3	2	1	1	1	2	1	1	3	4	1.88	1.09
9	1	1	1	4	1	2	3	4	4	1	2	1	3	2	3	4	2.31	1.25
10	1	1	4	4	3	3	1	4	4	1	4	3	2	4	4	3	2.88	1.26
11	3	4	2	4	3	1	3	1	3	1	4	2	3	4	3	3	2.75	1.06
12	1	3	1	1	1	4	4	1	2	1	2	2	2	4	3	1	2.06	1.18
13	3	1	1	2	3	4	1	1	1	1	2	2	2	1	3	3	1.94	1.00
14	2	1	1	3	2	4	1	3	1	2	4	3	2	2	1	2	2.13	1.02
15	2	2	1	4	4	3	4	2	4	1	4	2	2	2	2	1	2.50	1.15
16	1	4	4	2	3	2	2	3	1	1	4	2	1	3	1	4	2.38	1.20
17	2	1	2	3	3	3	1	1	2	3	4	3	1	3	4	1	2.31	1.08
18	2	3	1	4	2	1	4	2	3	1	4	2	2	3	3	3	2.50	1.03
19	2	3	1	1	1	3	4	1	3	2	2	2	1	2	3	1	2.00	0.97
Overall																	2.37	0.34

In analyzing data regarding the participants' understanding of NOS in response to the adapted VNOS, instead of categorizing them into three categories as naïve, transitional and informed in an evaluative manner, the focus was placed on the potential of their understanding of NOS. In the process, their written answers were read and reread. Then, each sentence was coded if it reflected specific aspects of the NOS. As illustrated in Table 3, if a sentence referred to evidence, in either specific or general sense (e.g., fossils or observation, respectively), as necessary for making scientific knowledge, it was coded as empirical NOS. Also, if a sentence referred to making inference based on available evidence, it was coded as inferential NOS accordingly. In doing so, it was notable that one sentence could reflect more than one aspect of NOS. For instance, participant no. 2 wrote, "From fossils found, (scientists) compare with animals at present and infer accordingly (for what they ate)". An empirical NOS code was provided for the fossil found as it is required to make scientific knowledge about dinosaurs. For the same sentence, an inferential NOS was provided as it clearly stated that only fossils are not sufficient for scientists to make a conclusion about dinosaurs. Such a sentence reflects not only an understanding of the two NOS aspects but also the relationship between them. However, it was also noticeable that none of the written responses can be coded as sociocultural NOS. Perhaps, this is because sociocultural influence on science is largely ignored in Thailand's science education. Thus, this aspect was excluded in further analysis. Once individually done, the coded data were shared and discrepancies discussed until a satisfactory consensus was reached.

Table 3. Examples of coding participants' written responses regarding NOS.

Code	Meaning	Illustrative Example
Empirical NOS	Scientific knowledge has basis in empirical evidence.	"(Science) has experiments to find facts to refute arguments." (no. 12)
Inferential NOS	Scientific knowledge involves making inference based on evidence.	"From fossils found, (scientists) compare with animals at present and infer accordingly." (no. 2)
Subjective NOS	Scientific knowledge is influenced and driven by scientists' personal subjectivity.	"Each (scientist) may have a different point of view." (no. 2)
Imaginative/Creative NOS	Scientific knowledge is the product of human creativity and imagination.	"If hypotheses are made without imagination about what we find, we may not get new ones." (no. 2)
Tentative NOS	Scientific knowledge is subject to change.	"Scientific (knowledge) is not certain; (it) can change." (no. 12)

In further analysis, each biology teacher's understanding of five NOS aspects was mapped into a pentagon. Each angle of the pentagon represents one NOS aspect, while the connecting line between two angles represents the relationship between their corresponding NOS aspects. The number at each angle represents the frequency of the participant mentioning each NOS aspect, while the number close to each line represents the frequency of the participant making the connection between the two NOS aspects.

As illustrated in Figure 2, participant no. 12 made sentences referring to the empirical NOS 6 times, out of which only once was his sentence coded as the tentative NOS. He also made the connection between these two NOS aspects 4 times. Using this method, each participant's understanding of NOS was graphically presented. This is also helpful to visualize which aspects he or she was certain about and which ones he or she was less certain about or did not even comprehend correctly. Using frequency numbers representing each NOS aspect and those representing each connection between two NOS aspects, it was found that the data regarding NOS were not normally distributed at .05 (W = .878, p = .001), based on the Shapiro–Wilk test (Morgan et al., 2013). This is because, as summarized in Table 4, most of the participants lacked proper understanding of some NOS aspects. Nonetheless, there was found a tendency that the more the participants referred to the NOS aspects, the more they made a connection between them as the Pearson's correlation coefficient was high (r = .940, p = .000).

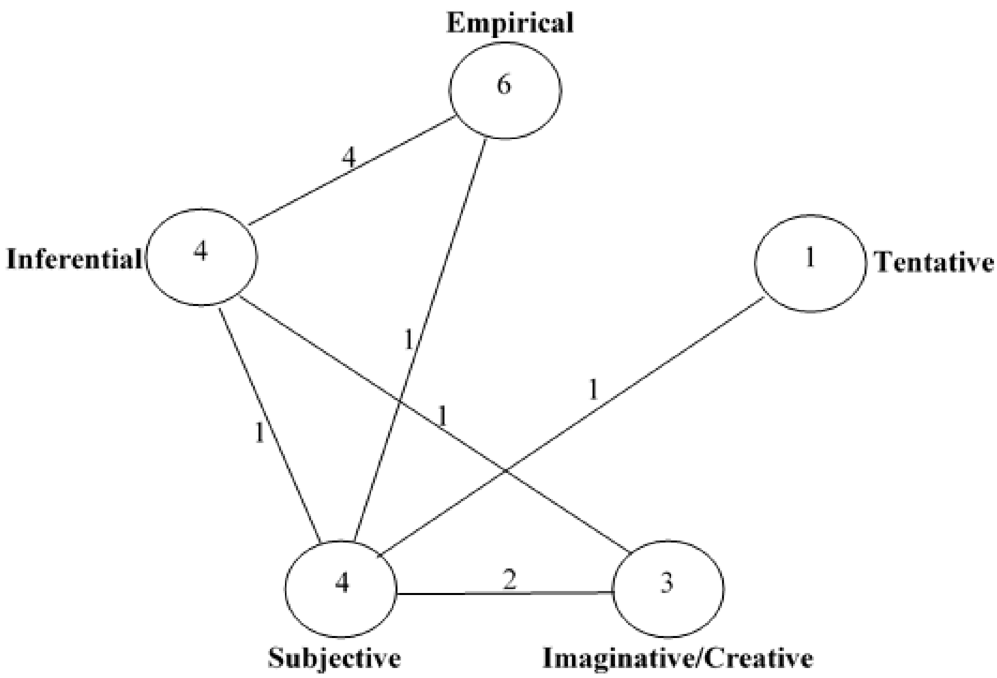

Figure 2. Participant no. 12's understanding of the NOS, as represented by a pentagon

Table 4. Participants' understanding of individual NOS aspects and connections between them.

No.	NOS aspect						Connection
	Empirical	Inferential	Subjective	Imaginative /Creative	Tentative	Sum	
1	2	0	1	1	1	5	1
2	5	1	1	1	1	9	4
3	3	0	0	1	1	5	0
4	5	0	1	1	0	7	1
5	4	3	1	1	1	10	3
6	7	2	1	1	1	12	5
7	3	0	1	2	1	7	2
8	2	1	1	1	1	6	1
9	2	1	3	0	1	7	2
10	3	0	1	0	2	6	2
11	4	1	1	1	1	8	2
12	6	4	4	3	1	18	10
13	3	1	1	1	1	7	3
14	4	0	1	1	1	7	0
15	2	0	1	1	1	5	0
16	2	0	0	1	1	4	0
17	4	0	2	1	1	8	3
18	3	2	0	1	1	7	2
19	5	1	0	1	1	8	1
Sum	69	17	21	20	19	146	42
M	3.63	0.89	1.11	1.05	1.00	7.68	2.21
SD	1.46	1.15	0.99	0.62	0.33	3.13	2.35

Results and Discussion

This study aimed to explore 19 first-year preservice biology teachers' initial OTSs and to examine whether those OTSs correlated with their understanding of the NOS. Analysis of the data collected using the modified POSTT for measuring their OTSs revealed that, by average, the participants tended to have OTSs between 'active direct' and 'guided inquiry'. This result supported what Dahsah & Faikhamta (2008) reported that science education reform in Thailand is in the process of transition from direct instruction towards an inquiry-based one. Since these first-year preservice biology teachers had just completed basic education and were studying only one educational course in the university, it is highly likely that the expressed OTSs resulted from their prior experiences as students in schools (Lortie, 1975) where science is taught mainly through hands-on activities and/or guided inquiry, especially in the format of the 5Es inquiry cycle which is an instructional approach long supported in Thailand (Faikhamta & Ladachart, 2016).

Analysis of the data gathered using the translated VNOS for eliciting their understanding of the NOS showed that while the empirical NOS was well realized by most of the participants, the other four aspects of the NOS were largely ignored by many participants, especially the inferential NOS, which was mostly referred to in connection with the empirical NOS (see Figure 3). It has been found in a case study by the researchers that Thai students may perceive evidence as self-evident without making inferences and reasoning (Ladachart & Suttakun, 2012). Perhaps, this is because many Thai science teachers do not devote their time to scientific inferences based on empirical evidence (Suttakun & Ladachart, 2013) because of them being in too much of a hurry to bring that evidence to a scientific conclusion. As a consequence, many Thai students may have less opportunities to practice making inferences based on empirical evidence (e.g., experimental results), assuming that such evidence is sufficient and self-evident, which results in understanding empirical NOS well but a lacking in the understanding of inferential NOS as appeared in this study with first-year preservice biology teachers who had just completed basic education.

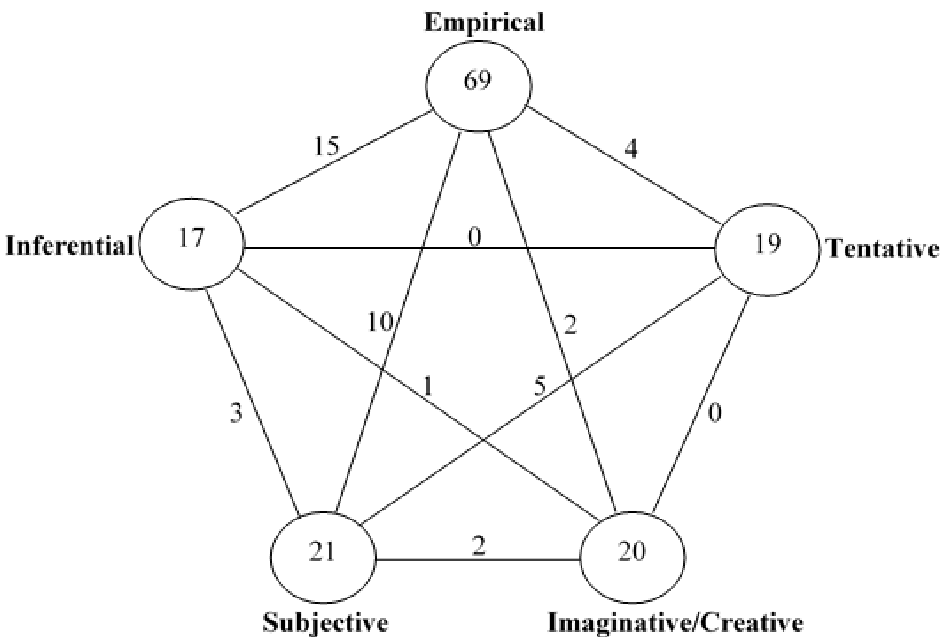

Figure 3. Participants' understanding of the NOS, as represented by a pentagon

Regarding the relationship between their understanding of the NOS and OTSs, Figure 4 visualizes a scatter plot between these two variables whose Pearson's correlation (Morgan et al. 2013) is slightly negative but not statistically significant ($r = -.227$, $p = .351$). This result suggests that understanding of the NOS may not be a dimension of OTSs as proposed by Friedrichsen et al. (2011). Moreover, this result is not consistent with that of Tsai (2002) which showed interrelations between science teachers' beliefs of teaching, learning and science. Perhaps, what made the difference between the result of this study and that of Tsai (2002) is the nature of the participants. While the participants in Tsai's (2002) were experienced science teachers, those in this study were first-year preservice science teachers. The authors have learned from their previous study that experienced science teachers tend to have a strongly held conception regarding teaching, the dimension of OTS according to Friedrichsen et al. (2011), while novice science teachers tend to possess a looser conception of teaching (Ladachart, 2011). Perhaps, this may be the reason why the freshmen preservice biology teachers in the present study did not show a positive tendency as regards their initial OTSs and understanding of the NOS as it appeared in Tsai's (2002) study.

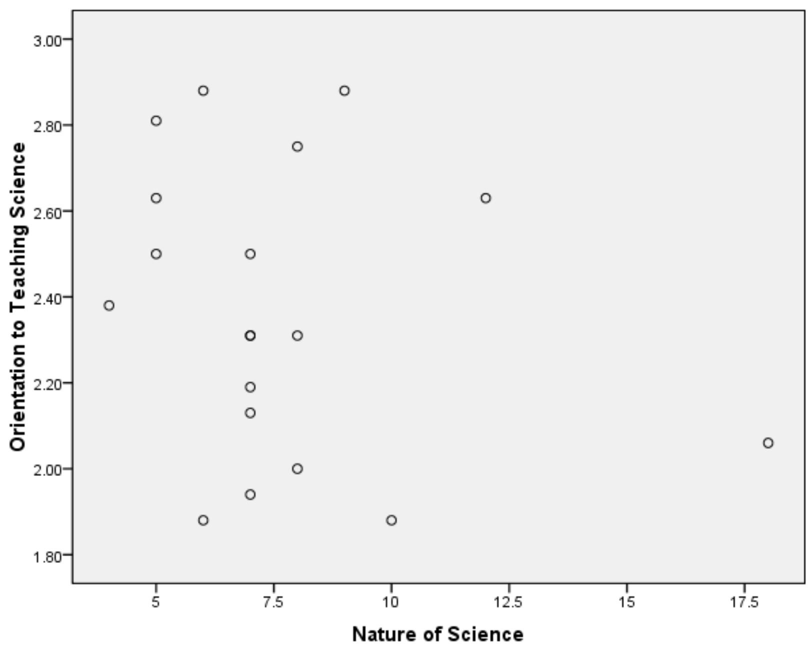

Figure 4. Participants' OTSs and understanding of NOS

On the other hand, the result of this study supported that of Demirdogen (2016) in that preservice science teachers' understanding of the NOS has no direct interaction with their PCK. In other words, possessing an informed understanding of the NOS (e.g., an understanding of how scientific knowledge is constructed) does not guarantee that science teachers will teach science in manners that allow their students to construct scientific knowledge (Lederman, 1999; Mellado, 1997). It is more likely that the NOS is viewed as a subject-specific content like combustion, electricity and plant growth (Faikhamta, 2013), and not as a component or dimension of OTSs (Kind, 2016). As in the case of teachers teaching other subjects in science, science teachers should be facilitated to develop PCK for teaching the NOS (Hanuscin, Lee, & Akerson, 2011) since learning about the NOS tends to be like learning a cognitive domain (Abd-El-Khalick & Lederman, 2000). Developing the understanding of the NOS alone does not necessarily lead to inquiry-based OTSs unless other supporting experiences (see Avraamidou, 2013) are provided.

Implications

This study has both theoretical and practical contributions. As for the theoretical one, it makes an issue of the nature of OTSs clearer in that OTSs, at least those held by first-year preservice biology teachers in the study, tend not to be associated with their understanding of the NOS. This theoretical contribution leads to a practical one, suggesting that science teacher educators cannot assume that developing informed understanding of the NOS among preservice science teachers will lead to inquiry-based OTSs. However, this does not devalue the efforts made in developing preservice science teachers' understanding of the NOS, which is a component of scientific literacy as a key goal of science education (Lederman, Lederman, & Antink, 2006). In other words, developing inquiry-based OTSs may need a different pathway. Based on Schneider & Plasman's (2011) review on learning progression for PCK, which suggests that "teacher thinking appears to progress first to thinking about learners, then to thinking about teaching, and finally to building a repertoire" (pp. 555), focusing on students' nature and characteristics (e.g., their preconceptions about scientific phenomena) may serve as a starting point in the preparation of preservice science teachers to develop inquiry-based OTSs and PCK. Recently, research has found strong connections among science teachers' orientations to science teaching, knowledge of student understanding, and knowledge of instructional strategies (Suh & Park, 2017).

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