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Analysis of Laboratory Videos of Science Teacher Candidates with Many-Facet Rasch Measurement Model

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Abstract

Aim of the present study is to analyze science teacher candidates' laboratory videos by using Many-facet Rasch model. Survey method was used in the study. The study was conducted in 2017-2018 academic year spring semester. Rasch model's surfaces are respectively: 9 juries, 13 science activities and 19 criteria. FACETS program was used for data analysis. Findings reveal that laboratory video, which was coded as SA8, was found to be the most successful and SA1 coded video was found the most unsuccessful with respect to criteria. The simplest articles which science teacher candidates were subjected are "introducing yourself", "using proper costume", "appropriate time" and the articles for which the science teacher candidates are constrained mostly "sound-supporting effect", "writing effect", "warning for security precautions". Jury numbered 3 or coded as J3 is "the most lenient" and scorer numbered 2 is "the severest" when juries are sequenced from the most lenient. Moreover, it could be said that, some of the jury members were extremely severe or lenient against some science activities according to bias analysis.

Introduction

Laboratory is one of the main part of and plays a central role science education (Hofstein & Lunetta, 1982; Hofstein & Mamlok-Naaman, 2007). The science laboratories have been considered as the most convenient place to teach science. Since students perform experiments to learn science in science laboratories, teaching can be more effective with respect to other learning environments such as classrooms. Laboratory activities in science education provide opportunities to develop scientific concepts, improve interest and motivation, and acquire problem solving and scientific practical skills, scientific habits of mind and understanding of nature of science (Bopegedera, 2011; Deiner et al., 2012; Roth, 2013; Walker & Sampson, 2013).

In order to make possible the provided opportunities through laboratory teaching for the science students, science teachers need to have specific field knowledge and pedagogical field knowledge (Boesdorfer & Lorsbach, 2014). First, science teachers need to have deep understanding on a specific science concept especially for the abstract ones. Then, they need to decide or design for the convenient laboratory activity with the consideration of their science laboratory opportunities, student profile, and their understanding. Later, they need to implement the laboratory activity as possible as they designed and be ready for the unexpected situations. Finally, they need to make assessment for each laboratory activity in order to be sure that their students get well from the opportunities of science laboratory. After all these efforts, the perfect achievement is not guaranteed as much as expected since science students need to be active participants of the laboratory activities. In other words, science laboratory activities can easily become science cookbook activities which mean doing somewhat scientific activity without making any sense (Herron, 2009).

Since early 1800s, the science education researchers performed too much effort through searching to bring better science education understanding and prevent science laboratories to become science kitchens (Pickering, 1993). When the literature reviewed on teaching science through laboratories, it was seen that researches on science teaching laboratories mostly focused on teaching science issues (Donnelly, 1998). The researches were conducted to increase understanding of the issues which are hard to understand since including the abstract concepts or occur at micro level rather than observed through naked eye (Pickering, 1993). In addition, the effects of science teaching in laboratories searched in terms of achievements, attitudes, and skill developments (Hasson & Yarden, 2012). However, only the limited number of researches focused on role of teachers and teacher education in science teaching in laboratories (Bond-Robinson & Rodriques, 2006; Greene, 2000; Roth et al., 2009). Determining the opinions of teachers and prospective teachers provide important benefits for science educators in order to improve the performance of science education process. So, it was aimed to determine opinions of science teacher candidates on laboratory videos related to science laboratory activities.

Technology or laboratory approach was embedded in the instruction, students learn better and their attitudes increase (Oymak & Ogan-Bekiroglu, 2017). "Video is generally thought to be a valuable medium for exploring teaching and learning because it captures much of the richness of the classroom setting" (Sherin, Linsenmeier, & van Es, 2009, p. 214). Laboratory videos may be evaluated with the help of Many-facet Rasch measurement model. As evaluating the measurement tools, two theories are commonly used: Classical Test Theory and Item Response Theory. Even though there are similarities between these theories it can be said that Item Response Theory has some advantages (Hambleton & Swaminathan, 1985). According to the Classical Test Theory, measurement is a matter of a certain amount of error, observing the knowledge and skills to be measured and converting the results of the observations into numbers and symbols. In Classical Test Theory an examinee's observed score can be expressed as; $X = T + E$. In the equation, X is observed score, T is true score and E is error score (Crocker & Algina, 1986). With the help of models depend on Item Response Theory a linear relationship can be obtained, loss data can be overcome, accuracy of measurement can be estimated and results that do not meet standard values can be evaluated (Elhan & Atakurt, 2005; Aziz & Masodi, 2010).

Rasch model is one parameter logistic as well as static model within Item Response Theory (IRT). With the help of Rasch model each person with a certain amount of a given latent trait specifies the probability of a response. For Rasch model which is the simplest model based on Item Response Theory, the natural logarithm of the odds ratio is modeled by the difference between person's trait score and item's difficulty. The standard Rasch model with persons and items: $\log (P_{ni} / (1-P_{ni})) = B_n - D_i$. P_{ni} is the probability that person n will succeed on item I; person n has ability B_n and D_i is the difficulty of item (Linacre, 2014; Embretson & Reise, 2000). Severity or leniency of the juries was added to Rasch model for Many-Facet Rasch Measurement (Linacre, 1993). The simple general form of Many-facet Rasch model can be expressed as follows:

$$\log \frac{Pnijk}{Pnijk-1} = B_n\text{-}D_i\text{-}C_j\text{-}F_k$$

In the formula,
P_{nijk} is the probability of examinee *n* being awarded on item *i* by judge *j* a rating of *k*
P_{nijk-1} is the probability of examinee *n* being awarded on item *i* by judge *j* a rating of *k-1*
B_n is the ability of examinee *n*
D_i is the difficulty of item *I*
C_j is the severity of judge *j*
F_k is the extra difficulty overcome in being observed at the level of category *k*, relative to category *k-1* (Linacre, 1989).

Rasch model which is one parameter logistic model depends on Item Response Theory and explained in "Some Probabilistic Models for Intelligence and Attainment Tests" book by George Rasch (Rasch, 1960). Rasch model and Many-facet Rasch model approach has been used in a steadily increasing number of applications in the fields of language testing (Bonk & Ockey, 2003; Eckes, 2005), educational and psychological measurement (Yılmaz & Sözer, 2018; Köse, Sözbir & Kalender, 2017; Ismail, Roslan, Adnan, 2017; Çetin & İlhan, 2017; Chang & Engelhard, 2016; Ahmad, Ali & Zainudin, 2011; Semerci, 2011a, Semerci, 2011b; Kaya Uyanık, Güler, Taşdelen Teker & Demir, 2017), health sciences (Park, Kim, Cha, Minn, Kim & Kim, 2018).

Aims of the study

The aim of the study is to make "Analysis of laboratory videos related to science activities with Many-Facet Rasch measurement model". In parallel with this purpose;

1. Analysis of science activities performance,
2. Criterion hardness analysis,
3. Analysis concerning severity/leniency of the juries and
4. Jury bias analysis were performed.

Method

In the study survey method was used. The observed data were analyzed by Many-Facet Rasch model. The facets or surfaces used laboratory videos of science teacher candidates; judge severity/ leniency and the relevancy of the used items: 9 juries, 13 science activities and 19 items or criteria. Jury was coded as J1, J2, … , J9; 13 science activities were coded as SA1, SA2, … , SA19 and criteria were coded as abbreviation.

Study group

The study was conducted in 2017-2018 academic year spring semester. 9 science teacher candidates were included in the peer assessment process. Linacre (1993) stated that in the Rasch measurement model, there is no assumption that the results of the data obtained from the sample are generalized to the universe. That’s why “study group” concept was used in the study. Teacher candidates prepared science activities under first author supervision. These science activities were coded as: SA1: Nutrient content, SA2: Force measurement, SA3: Friction, SA4: Friction and mass, SA5: Melting and freezing, SA6: From gas to liquid or vice versa, SA7: Boiling water, SA8: Pure substances, SA9: Boiling temperature of water, SA10: From ice to liquid or vice versa, SA11: Naphthalene dissolution, SA12: Water temperatures change, SA13: Expansion and contraction.

Research data

Assessment or criteria form (Kara & Bakirci, 2017) was examined and 19 items were arranged in 5-pointed Likert type between “not appropriate” corresponding to 1 and “completely appropriate” corresponding to 5. Criteria were indicated in Table 1. Expert opinion was obtained from one expert of measurement and evaluation and three experts of science education department. After experts approved the form in terms of usability and clarity of statements, it was used for the study. Cronbach’s α coefficient for reliability was calculated as .89. The quantitative data obtained in the study were analyzed with Many-facet Rasch model. FACETS 3.71.4 program was used to analyze data (Linacre, 2014).

Findings

When taking into consideration the analysis of laboratory videos or science activities of the science teacher candidates with many-facet Rasch measurement model the surfaces used in study (laboratory videos, severity/leniency of the juries and criteria) and the general information concerning these surfaces are given in Figure 1. The measure on the left side of Figure 1 is the logit measurement located between (-) and (+) and same for three surfaces.

Figure 1. Laboratory videos, judges and criteria summary report (calibration map)

The general information concerning these surfaces are given in calibration map in Figure 1. According to Figure 1, J3, J4 and J6 scored above the intermediate level on the other hand J9, J1, J7, J8 and J2 scored science activities below the intermediate level. SA8 is the most sufficient activity with respect to criteria. Logit values and more detailed information about calibration map were indicated in Table 1.

Table 1. Logit values for jury, science activities and criteria

Jury	Logit	Science Activity	Logit	Criteria	Logit
J3	.51	SA8: Pure substances	5.21	Introducing yourself	2.98
J4	.45	SA11:Naphthalene dissolution	2.59	Proper costume	.95
J6	.25	SA13: Expansion and contraction	2.30	Appropriate time	.30
J5	.02	SA12: Water temperatures change	2.07	Clear inference	.26
J9	-.07	SA7: Boiling water	2.04	Image quality	.19
J1	-.14	SA10: From ice to liquid or vice versa	2.04	Security precautions	.14
J7	-.28	SA6: From gas to liquid or vice versa	2.01	Using experimental processes	.07
J8	-.35	SA4: Friction and mass	1.83	Describing experimental process	.07
J2	-.39	SA9: Boiling temperature of water	1.53	Meaning of result	.01
		SA5: Melting and freezing	1.34	Introductory information	-.08
		SA3: Friction	1.32	Viewing angle	-.12
		SA2: Force measurement	1.20	Instruction sequence	-.18
		SA1: Nutrient content	.52	Material selection	-.20
				Clear voice	-.21
				Sound quality	-.39
				Gesture	-.61
				Warning for security precautions	-.88
				Writing effect	-1.01
				Sound-Supporting effect	-1.30

According to Table 1 it can be said that laboratory video numbered as SA8 (logit= 5.21) is successful at higher level, laboratory video numbered as SA1 (logit= .52) is successful at the lowest level. The most lenient jury is number J3 (logit= .51) and the severest member of jury is number J2 (logit= -.39). It was observed that the most difficult criteria is "Sound-supporting effect (logit= -1.30)" as well as "writing effect (logit=-1.01)" amongst the evaluation criterions of laboratory videos. It could be said that, these criterions were met at lower level in reference to other criterions. The easiest criterion is "introduction yourself (logit= 2.98)" and "using proper costume (logit= .95)".

Science activities performance analysis

A detailed measurement report including laboratory videos related to science activities of the science teacher candidates are shown in Table 2 which indicates that RMSE or Root Mean Square Standard Error was found .31 and the number is lowered than critical value standard deviation was found 1.06. Reliability was calculated as .92. This reliability value shows at which reliability the laboratory videos were evaluated. This coefficient .92 shows that science teacher candidates are graded in a high reliability.

Table 2. Science activities measurement

Science Activities	Nu	Measure	Model S.E	Infit	ZStd	Outfit	ZStd	Total Score	Obsvd Average
SA8	8	5.21	1.00	.98	.3	.38	.0	759	4.99
SA11	11	2.59	.24	.80	-.4	.86	-.1	745	4.90
SA13	13	2.30	.20	1.41	1.1	1.76	1.5	739	4.86
SA12	12	2.07	.17	1.05	.2	2.11	2.2	732	4.82
SA7	7	2.04	.17	1.27	.9	.67	-.8	731	4.81
SA10	10	2.04	.17	1.13	.4	.78	-.4	731	4.81
SA6	6	2.01	.16	1.57	1.7	.96	.0	730	4.80
SA4	4	1.83	.14	1.08	.3	.86	-.2	717	4.75
SA9	9	1.53	.11	1.23	1.0	1.01	.1	703	4.63
SA5	5	1.34	.10	1.26	1.3	.74	-.8	684	4.53
SA3	3	1.32	.10	1.29	1.5	1.37	1.2	685	4.51
SA2	2	1.20	.09	1.11	.7	.96	.0	702	4.42
SA1	1	.52	.07	.69	-3.1	.69	-1.8	635	3.71
RMSE (Model): .92 x^2=309.6 df: 12 p= .00									

Null hypothesis was rejected when "there is a measurable distinction amongst the laboratory videos of science teacher candidates" hypothesis that belongs to fixed effect with separation index 3.39 and reliability coefficient .92 was tested with chi-square test (x^2=309.6, df: 12, p= .00). This conclusion shows that there are significant distinctions between the laboratory videos of science teacher candidates in terms of statistical. The qualification sequence of performance tasks is as follows: SA8, SA11, SA13, SA12, SA7, SA10, SA6, SA4, SA9, SA5, SA3, SA2 and SA1.

Criteria Difficulties Analysis

Criteria measurement report are given for the criteria used evaluation of science activities in Table 3. Separation index was found 2.93 and reliability coefficient was found .90. Null hypothesis was rejected when "there is significant distinctions between difficulties of articles used in evaluation of science activities" hypothesis was tested with chi square (x2= 258.6, df: 18, p= .00). According to these results, there is a significant distinctions between articles used in evaluation of science activities statistically. According to Table 3 the simplest articles which science teacher candidates were subjected are "introducing yourself", "using proper costume", "appropriate time" and the articles for which the science teacher candidates are constrained mostly "sound-supporting effect", "writing effect", "warning for security precautions".

Table 3. Criteria measurement report

Criteria	Meas.	S.E	Infit	ZStd	Outfit	ZStd	Total.score	Obs. Aver.
Introducing yourself	2.98	1.00	.98	.4	.53	.4	529	4.99
Proper costume	.95	.34	1.40	1.9	3.08	1.9	517	4.92
Appropriate time	.30	.22	.54	-.7	.51	1.05	503	4.84
Clear inference	.26	.21	.48	-.6	.57	1.04	507	4.83
Image quality	.19	.20	.98	.7	1.39	.91	510	4.81
Security precautions	.14	.19	1.39	.3	1.07	1.03	504	4.80
Using experimental processes	.07	.18	.48	-.9	.51	1.05	502	4.78
Describing experimental process	.07	.18	.61	-.9	.49	1.06	502	4.78
Meaning of result	.01	.18	.66	-.1	.82	.95	500	4.76
Introductory information	-.08	.17	.99	-.6	.65	1.07	497	4.73
Viewing angle	-.12	.16	.83	-.2	.81	1.05	500	4.72
Instruction sequence	-.18	.15	.62	-.9	.56	1.02	493	4.70
Material selection	-.20	.15	1.38	.0	.96	1.17	492	4.69
Clear voice	-.21	.15	1.20	.2	1.07	.94	496	4.68
Sound quality	-.39	.13	.76	-.3	.79	.94	487	4.59
Gesture	-.61	.12	1.00	-.1	.87	.94	469	4.47
Warning for security precautions	-.88	.10	1.04	.7	1.26	1.21	447	4.26
Writing effect	-1.01	.10	1.40	1.4	1.53	.93	435	4.14
Sound-Supporting effect	-1.30	.09	1.54	2.0	1.69	.67	403	3.80

Seperation: 2.93 Reliability: .90 x^2= 258.6, df: 18, p= .00

Analysis of Jury

Severity/leniency comparison of jury is given in Table 4. Jury separation index is 2.74 and reliability coefficient is .88 in Table 4. Null hypothesis was rejected when "there is distinction between severity/leniency of jury" hypothesis was tested with chi-square test (x2=73.2, df=8, p= .00). According to these results, there is a significant distinction between severity/leniency points of the five evaluators statistically. It could be said that the scorer numbered 3 or coded as J3 is "the most lenient" and scorer numbered 2 is "the severest" when juries are sequenced from the most lenient towards the severest in Table3. Juries may be sequenced from the severest to the most lenient as J2, J8, J7, J1, J9, J5, J6, J4 and J3.

Table 4. Jury measurement report

Jury	Nu	Measure	Model S.E	Infit	ZStd	Outfit	ZStd	Total Score	Obsvd Average
J3	3	.51	.14	1.06	.3	.84	.0	1193	4.83
J4	4	.45	.13	.87	-.5	.36	-1.3	1190	4.92
J6	6	.25	.12	1.85	3.2	1.81	1.4	1177	4.90
J5	5	.02	.10	.90	-.4	1.43	.9	1158	4.88
J9	9	-.07	.17	.52	-1.8	.41	-1.2	99	4.86
J1	1	-.14	.09	.98	.0	.52	-1.2	1136	4.85
J7	7	-.28	.09	1.27	1.6	1.05	.2	1120	4.83
J8	8	-.35	.08	.87	-.8	1.13	.4	1113	4.81
J2	2	-.39	.08	1.08	.5	1.00	.1	1107	4.80
Seperation: 2.74 Reliability: .88 x^2=73.2, df=8, p= .00									

Jury Bias Analysis

Bias/interaction graphic can concrete the situation and absolute measure of jury and science activities can be examined. The bias analysis of the jury is given in Table 5.

Table 5. Bias/interaction report

Obs. Score	Exp. Score	Obs. Count	Obs-Exp Avarage	Ju	measr	SA	Act. Measure
75	91.89	19	-.89	J5	.02	SA12	2.07
66	84.92	19	-1.00	J1	-.14	SA5	1.34
62	81.24	19	-1.01	J8	-.35	SA3	1.32
66	82.84	19	-.89	J1	-.14	SA2	1.20
84	91.10	19	-.37	J2	-.39	SA13	2.30
87	92.46	19	-.29	J6	.25	SA6	2.01
87	92.27	19	-.28	J2	-.39	SA11	2.59
70	81.37	19	-.60	J4	.45	SA1	.52
87	91.78	19	-.25	J5	.02	SA7	2.04
51	63.47	19	-.66	J7	-.28	SA1	.52
90	93.11	19	-.16	J3	.51	SA6	2.01
94	94.83	19	-.04	J8	-.35	SA8	5.21
95	93.67	19	.07	J6	.25	SA11	2.59
95	93.54	19	.08	J4	.45	SA13	2.30
95	93.22	19	.09	J3	.51	SA12	2.07
95	93.17	19	.10	J3	.51	SA7	2.04
95	93.11	19	.10	J4	.45	SA12	2.07
95	93.05	19	.10	J4	.45	SA7	2.04
95	93.05	19	.10	J4	. 45	SA10	2.04
95	92.96	19	.11	J1	-.14	SA11	2.59
95	92.52	19	.13	J4	.45	SA4	1.83
95	92.39	19	.14	J8	-.35	SA11	2.59
95	92.15	19	.15	J1	-.14	SA13	2.30
95	91.30	19	.19	J8	-.35	SA13	2.30
95	91.20	19	.20	J1	-.14	SA12	2.07
95	91.06	19	.21	J1	-.14	SA7	2.04
95	91.06	19	.21	J1	-.14	SA10	2.04
95	90.92	19	.21	J1	-.14	SA6	2.01
94	90.44	19	.19	J7	-.28	SA12	2.07
95	90.79	19	.22	J3	.51	SA5	1.34
95	90.11	19	.26	J7	-.28	SA6	2.01
90	84.93	18	.28	J1	-.14	SA4	1.83
95	89.99	19	.26	J8	-.35	SA12	2.07
95	88.80	19	.27	J8	-.35	SA7	2.04
95	89.31	19	.30	J2	-.39	SA6	2.01
93	87.16	19	.31	J1	-.14	SA9	1.53
87	72.13	19	.78	J5	.02	SA1	.52
87.7	87.7	18.9	.00		Mean (Count: 106)		
10.2	9.05	1.2	.28		S. D. (Pouplation)		
10.2	9.09	1.2	.28		S. D. (Sample)		
Fixed (all=0) chi-square: 254.3 d.f. : 106 significance (probability): .00							

It could be said that, some of the jury members were extremely severe or lenient against some science activities according to bias analysis. For instances it was observed that, J8 made an extremely severe scoring by giving 62 point for science activities although jury was expected to give nearly 82 point in the evaluation related to science teacher candidates' science activity (SA3). A similar case is for J1 that J1 gave S5 66 point instead expecting to give about 85. On the other hand lenient scoring was also observed. J5 gave SA1 87 point instead expecting to give 72. 13. For more detailed information about jury bias, Table 5 may be examined. In Figure 2 bias/interaction graphic is given.

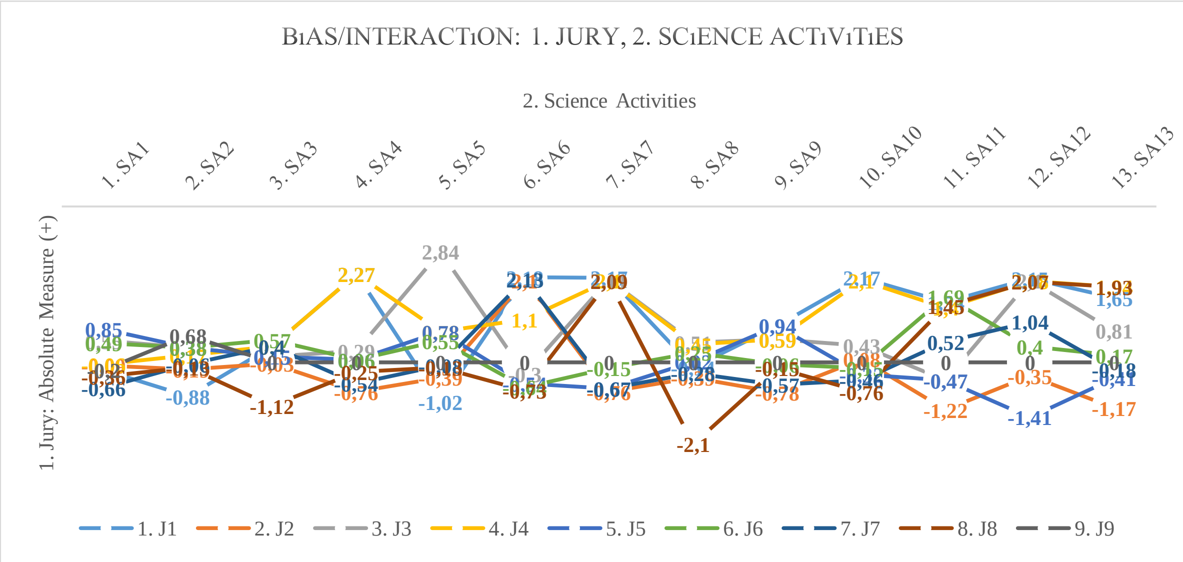

Figure 2. Bias/interaction graphic

Conclusion and Recommendations

The Rasch model has two main advantages. First one is specific objectivity and second one is that its stability although it may be used for small samples (Fischer 1997; Fischer 2005; Linacre 1994; Linacre, 2006). In this study, the analysis was performed for videos of science teacher candidates related to laboratory activities with many-facet Rasch measurement model. The surfaces of model were jury, laboratory videos and criteria. Reliability coefficient of Rasch analysis is similar to Cronbach alpha or KR-20 (Linacre, 1997). Measurement report of Many-Facet Rasch measurement model indicate reliability coefficient. In this study, reliability coefficients were calculated 0.92 for science activities performance analysis, 0.88 for jury analysis and 0.90 for criteria difficulties.

The laboratory video which was coded as SA8, was found to be the most successful and SA1 coded video was found most unsuccessful with respect to criteria. Jury numbered 3 or coded as J3 is "the most lenient" and scorer numbered 2 is "the severest" when juries are sequenced from the most lenient. It could be said that, some of the jury members were extremely severe or lenient against some science activities according to bias analysis. In the literature differences in rating process between raters or juries can be determined.

The videos prepared by science teacher candidates related to science experiments were subjected to performance analysis. The results of the analysis reveal that the videos of laboratory activities prepared by the science teacher candidates differ in terms of the evaluation criteria. In the reflection of the videos prepared by science teacher candidates on the performance analysis results, teacher candidates' ability to prepare different videos, their knowledge, attitude and interest, pedagogical competencies have been effective (Christ et al., 2014). In addition, the evaluation criteria used were effective to a certain extent. Although, the criteria used in the assessment were determined at the beginning of the study and shared with prospective teachers, prospective teachers showed different performance in fulfilling the expectations (Christ et al., 2012). There is also the effect of the scores of the juries independently of each other in the performance difference. The fact that juries gave points or variable scores when giving points to videos gave rise to a result that could be seen as bias (Van Es et al., 2014).

The criteria used in the evaluation of the videos prepared by science teacher candidates about science experiments were subjected to difficulty analysis. Analysis results indicate that there are differences between the criteria used in the evaluation. In the videos of the science laboratory prepared by teacher candidates, it is understood that they can fulfill the narrator criteria such as ”introducing themselves and” using “proper costume”. On the other hand, it has been revealed that the teacher candidates have difficulty in technical subjects such as using “sound-supporting effect and “writing effect”. In addition, it is revealed that science teacher candidates have difficulty in covering the security issue such as laboratory safety in prepared videos. In this context, it was revealed that that science teacher candidates were not challenged in the narrator and activity process criteria when preparing videos, but they had difficulty in technical specifications and laboratory safety criteria. Even though teacher candidates have successfully completed computer course techniques including video editing techniques and laboratory safety techniques including video editing techniques, they have difficulty in gathering the competencies they acquired in different courses in order to prepare an instructional material. In the video analysis studies that focus on decision making justification (Rich et al ., 2008), reflective thinking, teaching skills (Nagro et al., 2017) and science achievements (Taylor et al., 2017) , teacher candidates are expected to they were forced to demonstrate the knowledge, skills and abilities they were expected to acquire. It is also effective that that teacher candidates work in a way to produce a product as well as having the knowledge and skills expected to show a comfortable or compelling attitude about fulfilling their expectations (Masats & Dooly, 2011).

The jury bias analysis was performed on the data obtained from the evaluation of teacher candidates' videos about science experiments. The results of the analysis indicate that there are bias among the juries that are in the evaluation. In fact, the juries that will conduct a video evaluation at the beginning of the study were briefed about the scope, importance and how to make the evaluation. However, because juries are independent of each other and they reflect the impressions they get from the evaluation videos in the direction of their knowledge, skills and abilities, they have different evaluation scores and jury biases (Semerci et al ., 2013). In addition, the juries were determined among the pre-service teachers. In other words, judges have made peer evaluation. Although it is assumed that juries will be evaluated in line with the research objectives and based on the evaluation criteria, criticism or over-criticism can be made in peer review (Şahin et al ., 2016) .

Şahin et al. (2016) analyzed peer assessment through Many-facet Rasch measurement model. The research was conducted with 91 graduate undergraduate students and with the lecturer. Semerci et al. (2013) aimed to make analysis of seminar presentation performances of postgraduate students. The study group included seven students and five juries observed their seminars. Some of the jury members were extremely severe or lenient against some post graduate students according to bias analysis. Study of European Council (2009) stated that Rasch measurement model doesn’t reveal biases but it indicates the references of biases and to which jury does biases belong to. The biases which appeared may have various reasons such as professional experience, personality traits, attitudes, demographic characteristics workload, and assessment purpose.

The simplest articles which science teacher candidates were subjected are “introducing yourself”, “using proper costume”, “appropriate time” and the articles for which the science teacher candidates are constrained mostly “sound-supporting effect”, “writing effect”, “warning for security precautions”. The results of the study were discussed with science teacher candidates and they were informed how they can develop their skills. It may be recommended that similar studies can be conducted with different measurement tools and raters. By this way researchers may analyze case objectively and define the educational materials.

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Testing Measurement Invariance of Academic Self-Efficacy Scale for Singapore, Spain and Turkey

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Abstract

A scale that does not measure the same structure in different cultures should not be used in the cross-cultural comparison-based studies. The validity of the scales should be tested primarily for the countries. In this study, as the evidence of validity of the Programme for International Student Assessment (PISA) 2015 science self-efficacy scale, the measurement invariance has been tested for different cultures. As determined in scientific studies, general self-efficacy is focused on more and this should be examined in academic self-efficacy known to be to student learning and achievement. In the analysis of the data, the measurement model is initially tested. Then, the measurement invariance is tested with a series of analysis. As a result, the scale confirms a unidimensional structure for each country. However, it has provided partial measurement invariance. This indicates that item-based analysis should be conducted.

Introduction

Determining the performance of the students and the related variables has an important place in educational research. Defended in terms of the effect of students' characteristics on learning, the most important approach is that the students' own behaviors are important in the development of their motivation towards the lesson and thus in the realization of learning. In this research, one of the student behavior's structure, the academic self-efficacy, is examined in terms of cultures. According to Bandura (1977a; 1977b) self-efficacy as one of the students' beliefs, is an important component in social cognitive theory. Self-efficacy can be assessed in three characteristics: Level, generality, and strength, throughout activities and contexts. The level of self-efficacy refers to the degree of difficulty of a given task. Generality, relates to the transferability of self-belief among activities. The strength of the efficacy is measured by the amount of certainty of carrying out a given task. Despite a general self-efficacy structure defined for everyone, Bandura states that self-efficacy is peculiar to a task and domain. Therefore, there are different kinds of self-beliefs, including social self-efficacy, emotional self-efficacy, and academic self-efficacy. The current study focused on academic self-efficacy (science self-efficacy), which concerns the individual's beliefs about his ability to reach the goals in the school context on his own. (Muris, 2001).

Academic self-efficacy is essential for learning and academic performance (Zimmerman, 2000). It is a positive predictor of academic achievement in different courses such as mathematics, reading, and science (Schunk, Pintrich, & Meece, 2008). In a meta-analysis study by Multon, Brown, and Lent (1991), it was stated that self-efficacy is a significant predictor of achievement and motivation in different population and environments. Similarly, low self-efficacy has been reported from low-performance students, while high-performance students has reported high self-efficacy and given greater value for their learning (Zusho, Pintrich, & Coppola, 2003).

The academic self-efficacy of the students is tried to be measured by determining their self-confidence levels based on a specific area or subject. It is important that the characteristics measured in cross-cultural studies indicate the same structure for each country. Although the concept of general self-efficacy has a universal structure, it is likely to be influenced by culture like any psychological variable. Therefore, the scale that has been used must be proven to measure the same structure and to be equivalent before any cross-cultural comparisons are conducted. Scholz, Doña, Sud, and Schwarzer (2002)'s study conducted in 25 countries, assesses whether self-efficacy has a universal structure or not. According to a relevant research, many intercultural differentiations have been determined although the general self-efficacy structure is found to be a universal concept. However, such differentiations have not been discussed in details. For example, it is determined that Japan has the lowest self-efficacy level while Costa Rica has the highest. The researchers state that this may arise from any intercultural differences as well as from uncontrollable conditions for data collection or from the fact that the sample is not selected properly.

Current study focuses on academic self-efficacy rather than general self-efficacy, and the sample includes Asian, Middle Eastern and European cultures with different languages and cultural backgrounds. It includes Singapore from Asia, Turkey from the Middle East, and Spain from Europe. Lifestyle, the way of cultivation and the differentiation in their language can also differentiate the self-efficiency context in which students upload their academic self-efficacy. In the research, the validity of the self-efficiency scale specified in the Programme for International Student Assessment (PISA) 2015 for these countries is tested by the measurement invariance. When the literature is examined, the number of studies which evaluate the academic self-efficacy structure based on cross-cultural studies is determined to be limited. Ansong, Eisensmith, Masa, & Chowa (2016) tested the measurement invariance of the self-efficacy scale adapted for Ghana by emphasizing the differentiation by gender but not tested for different cultures. Teo and Kam (2014) tested measurement invariance of the general self-efficacy scale for Germany and Singapore as different cultures. Kıbrıslıoğlu Uysal and Akın Arıkan (2018) did not examine the intercultural comparison, but only tested the measurement invariance of PISA 2015 and PISA 2006 self-efficacy scale by years for Turkey sample.

PISA is a large-scale assessment, which reveals what students learn and how they can use mathematics, science, reading literacy in their daily life. PISA collects information about the characteristics of students, teachers, and schools which are related to performance (Organisation for Economic Co-operation and Development [OECD], 2017a). Around 70 countries participate in the PISA and these countries guide their own education policies based on the results obtained. However, such international measurement and assessment practices also inevitably bring along like a league of skills. After the explanation of the results of each test, the rankings of the countries draw attention. Performance and characteristics of the students are compared by country. Although PISA is developed by the specialists, any students from different cultures are subject to this test, and this causes the question of whether the tests in PISA measure the same structures in each country or not. There is uncertainty about whether the differences in the scale mean scores can be attributed to actual differences between countries or to differences in measurement between countries due to cultural biases in response, translation errors or cultural differences in understanding the underlying structure (Rutkowski & Svetina, 2014). Without any evidence supporting measurement equivalence, any claim or conclusion on comparative differences will necessarily remain weak (Vandenberg & Lance, 2000). An important criterion for intercultural comparison of scores from a scale is to understand and measure the latent variable in all cultures in the same way. This characteristic is often called as measurement invariance (Meredith, 1993), the absence of differential item functioning (Hambleton & Rogers, 1989; Swaminathan & Rogers, 1990) or lack of bias (Lord, 1980). The measurement invariance relates to whether the items in a measurement tool state the same construct for the individuals in different groups or not. Generally, measurement invariance surveys focus on whether the latent variable (self-efficacy, etc.) can be compared between heterogeneous groups (Rutkowski & Svetina, 2014).

Method

Sample

In this study that aims at a comparison of the academic self-efficacy structures between the students from different cultures; a group of 15-year-old students, who study in Singapore, Spain, and Turkey, constitute the research group. When the PISA 2015 technical report (OECD, 2017a) is examined, it is understood that the sample is selected by stratified sampling method by taking any characteristics such as schools, regions, etc. into consideration. This scale is applied to 6115 students from Singapore, 6736 students from Spain and 5895 students from Turkey. The outliers are removed from the data to make the data suitable for analysis. After the outliers are removed, the research is carried out with the data of 5521 students from Singapore, 5260 students from Spain and 4633 students from Turkey.

Data Collection

PISA 2015 data which obtained by OECD is used for the analysis. PISA is a large-scale test conducted every three years since 2000. It aims basically at measuring the science, mathematics, and reading literacy of the students, and moreover, the surveys are conducted on the students, households, families, and schools. In current research, the science self-efficacy scale included in the student survey is used. This survey aims at showing how easy it will be for them if the students perform the tasks related to science. Accordingly, the survey contains eight items as follows (OECD, 2017b: 38):

How easy do you think it would be for you to perform the following tasks on your own?
1. Recognize the science question that underlies a newspaper report on a health issue.
2. Explain why earthquakes occur more frequently in some areas than in others.
3. Describe the role of antibiotics in the treatment of diseases.
4. Identify the science question associated with the disposal of garbage.
5. Predict how changes in an environment will affect the survival of certain species.
6. Interpret the scientific information provided on the labelling of food items.
7. Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars.
8. Identify the better of two explanations for the formation of acid rain.

For the items, there is a four-answer category: *I could do this easily, I could do this with a bit of effort, I would struggle to do this on my own, and I couldn't do this*. For Singapore, Spain, and Turkey, Cronbach alpha coefficients of internal consistency are calculated for the answers given to the self-efficacy scale and in turn .88, .89 and .91 values are obtained.

Data Analysis

Before the analysis is conducted, the data is prepared for the analysis and assumptions have been tested. After PISA 2015 data is downloaded for this, all the data of Singapore, Spain, and Turkey is selected and data of other countries are removed from the data set. Then, to determine the outliers, the Mahalanobis distance coefficients are calculated and the persons with $p < .001$ are deemed as the outlier (Mertler & Reinhart, 2016) then removed from the data set. The study has been carried out with the data of 5521 students from Singapore, 5260 students from Spain and 4633 students from Turkey.

The multivariate statistics are used for testing the measurement invariance. Therefore, any particular assumptions must be met. Multivariate normal distribution of data is tested to this end. For this, R 3.5.1 (R Core Team, 2018) is used as the statistic software and the Henze-Zirkler tests are conducted by MVN 5.5 software package (Korkmaz, Goksuluk, & Zararsiz, 2014). For three countries, the result of the Henze-Zirkler test is calculated as $p < .01$. This shows that the data doesn't meet multivariate normality assumption (Mecklin & Mundfrom, 2003). Therefore, the Robust Maximum Likelihood method is used in all estimates.

The semTools 0.5-1 (Jorgensen, Pornprasertmanit, Schoemann, & Rosseel, 2018) and semPlot 1.1 (Epskamp & Stuber, 2017) software packages are used for determining the measurement invariance. For this, firstly measurement model has individually tested via the confirmatory factor analysis for Singapore, Spain, and Turkey. Kline (2005) states that χ^2/df ratio must be equal to or less than 3.00, and Tabachnick and Fidell (2007) state that the values equal to or less than 0.80 are acceptable for RMSEA. The values less than 0.08 indicate a good fit for SRMR (Hu & Bentler, 1995), and the values larger than 0.95 indicate a good fit for CFI and TLI (Brown, 2006).

After the confirmatory factor analysis, to determine whether the measurement invariance is met or not for three countries, "configural invariance (equal form); metric invariance (equal factor loadings), scalar invariance (equal indicator intercepts) and strict factorial invariance (equal indicator error variances) are tested in turn. Brown (2006, p.268) stated that "Number of factors and pattern of indicator-factor loadings is identical across groups" for the configural invariance. Only the factor loadings are equal between groups in the metric invariance, and it's mean that respondents attribute the same meaning to the latent construct for all groups (van de Schoot, Lugtig, & Hox, 2012). Scalar invariance means that "the regression equations of the observed variables on the latent factors are equivalent across groups" (Schimitt & Kuljanin, 2008, p.212). And the strict invariance would be met if the indicator residuals are equal (Brown, 2006).

In the invariance study, $\Delta CFI \leq .01$ is recommended as a criterion by Cheung and Rensvold (2002) and Chen (2007). Meade, Johnson and Braddy (2008) state that ΔCFI and ΔNCI may be used and if ΔCFI value is equal to or less than .002, the measurement invariance is acceptable. In the TALIS technical report, OECD (2010) uses the criterion as $\Delta CFI \leq .01$ and states the criterion value may be flexed if the groups more than two are compared. Rutkovski and Svetina (2014) estimate that the criterion may be flexed approximately up to $\Delta CFI \leq .02$ in the measurement invariance study conducted with 10 and 20 groups. Since three groups are compared in this research, it is seen that $\Delta CFI \leq .01$ is suitable to be used as a criterion while determining the measurement invariance. The tested measurement model is given in Figure 1.

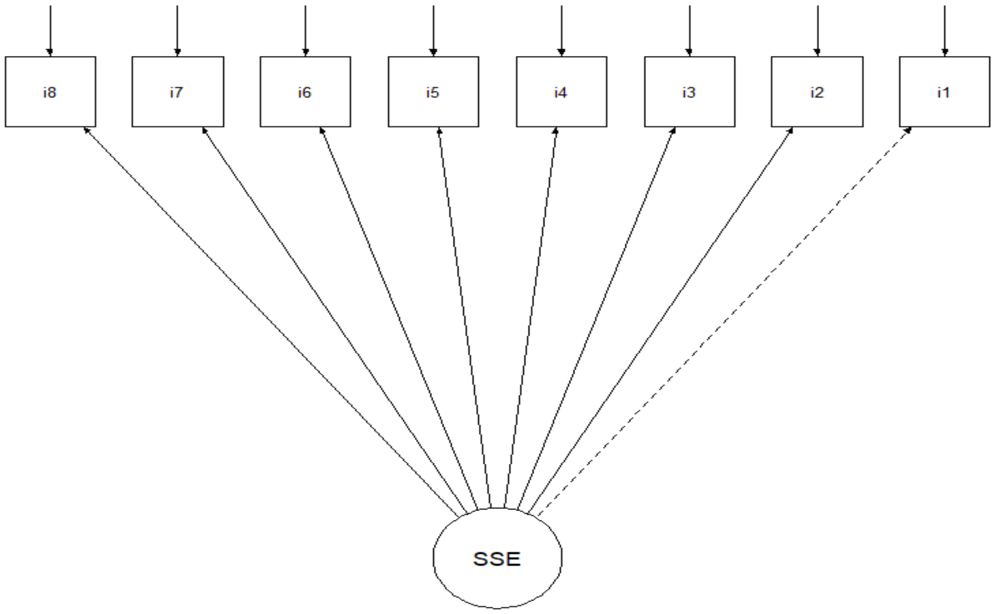

Figure 1. Tested measurement model

Results

Findings on Testing of the Measurement Model

Firstly, the measurement model shown in Figure 1 for Singapore, Spain, and Turkey is examined by the confirmatory factor analysis. The goodness of fit indexes obtained for confirmatory factor analysis is given in Table 1.

Table 1. Confirmatory factor analysis parameters for countries

	χ^2/sd	RMSEA [90%CI]	SRMR	CFI	TLI
Singapore	21.161	.060 [.056 - .065]	.030	.970	.959
Spain	19.041	.059 [.054 - .063]	.025	.976	.966
Turkey	25.776	.073 [.069 - .077]	.034	.958	.941

When Singapore, Spain, Turkey, and three countries are considered together (All-Data), according to table 1, the RSMEA, SRMR, CFI and TLI values show that the unidimensional structure is verified. Only χ^2/df value is out of the acceptable limits but χ^2 statistics depend on the sample size (Kline, 2005). As a result of the analysis, it is determined that the model is compatible with the data because the other fit indices are within acceptable limits. All the parameters obtained according to the confirmatory factor analysis results are shown in Table 2.

Table 2. Robust maximum likelihood estimates for self-efficacy scale

	Singapore				Spain				Turkey			
	UFL	SE	SFL	z	UFL	SE	SFL	z	UFL	SE	SFL	z
i1	1.000		.709		1.00		.716		1.000		.681	
i2	.994	.022	.620	44.065	.928	.019	.674	48.894	1.082	.021	.736	51.286
i3	1.237	.025	.721	48.551	1.103	.018	.737	60.830	1.197	.026	.744	45.706
i4	1.223	.024	.765	50.181	1.030	.017	.736	60.282	1.217	.027	.795	45.662
i5	1.155	.024	.755	48.372	1.095	.019	.760	58.250	1.212	.028	.789	43.568
i6	1.214	.025	.758	49.372	1.025	.019	.722	55.050	1.219	.028	.773	43.947
i7	1.212	.026	.691	46.766	1.057	.020	.708	53.529	1.164	.029	.688	40.815
i8	1.063	.024	.660	43.562	1.103	.020	.730	54.766	1.230	.028	.756	43.498

UFL: Unstandardized factor loadings; SFL: Standardized factor loadings; SE: Standard error

When the unstandardized factor loadings for the items and z values for these factor loadings are examined, it is observed that the factor loadings obtained for all items are significant. The goodness of fit indexes shown in Table 1 and the Robust Maximum Likelihood Estimates given in Table 2 are considered, it is understood that the science self-efficacy is measured unidimensional for all of the countries.

Findings on Testing of the Measurement Invariance

After the measurement model is verified for the countries, the invariance of the structure to be measured by the science self-efficacy scale between the countries is tested. For this, the configural, metric, scalar and strict invariance are tested in turn. As a result of the analysis, the fit indexes and ΔCFI values are examined. The findings on the analysis of the measurement invariance are given in Table 3.

Table 3. Findings on testing of the measurement invariance

Measurement invariance	df	χ^2	RMSEA	SRMR	TLI	CFI	ΔCFI
Configural	60	1337.121	.064	.027	.955	.968	
Metric	74	1556.188	.062	.036	.961	.966	.002
Scalar	88	3766.122	.090	.059	.922	.919	.047
Strict	90	4074.569	.093	.079	.918	.912	.007

When Table 3 is examined, it is understood that the self-efficacy scale provides the configural invariance (CFI > .95; RMSEA < .08). In other words, the science self-efficacy scale has the same factor structure for all three countries. Furthermore, the other findings provide additional evidence for configural invariance.

When the findings obtained for metric invariance are examined, it is observed that ΔCFI value is less than 0.01. Thus, the science self-efficacy scale also provides the metric invariance. In other words, the science self-efficacy scale shows invariance between the countries in terms of factor structure and factor loadings.

However, when the scalar invariance findings are examined, it is determined that ΔCFI value between the metric and scalar invariance models is larger than 0.01. Namely, the indicator intercepts and indicator error variances doesn't show invariance between the countries. Therefore, it is concluded that the PISA 2015 science self-efficacy scale has a partial invariance between Singapore, Spain, and Turkey.

Discussion and Conclusion

In the research, the structure and measurement invariance of the science self-efficacy scale, used in the PISA 2015 assessment, tested for Singapore, Spain and Turkey which have a different culture and language. The findings of the measurement invariance studies have important effects on the use of the scale in different cultures. A validated scale should be sensitive to measure changes in self-efficacy independent of cultural characteristics (Bialosiewicz, Murphy, & Berry, 2013).

The measurement models are tested by CFA for each country. According to the results obtained from the measurement model, the scale measures a unidimensional structure for all three countries. The unidimensional self-efficacy structure shown in the PISA 2015 report is verified. The researchers support that self-efficacy structure must be discussed in unidimension. Bandura et al. (1999) developed a scale to measure the general self-efficacy level of children. The scale measures three main areas of self-efficacy: Social self-efficacy, academic self-efficacy, and self-regulatory self-efficacy. Here, the academic self-efficacy structure is a dimension discussed under general self-efficacy latent variable. The general self-efficacy scale developed by Jerussalem and Schwarzer was tested by Sholz et al. (2002) for 25 countries and they found it as unidimensional. Ansong et al. (2016) also tested the unidimensional structure of the academic self-efficacy scale developed by Muris (2001) for Ghana and emphasized that the academic self-efficacy structure is a property measured in unidimensional. The researchers, who use the PISA data, may accept the academic self-efficacy as a unidimensional structure. Thus, the scale indicates how much confident the students feel in conducting their tasks related to science. However, this finding is not sufficient to make cross-cultural comparisons.

At the second step of the research, the measurement invariance of the scale is tested. The scale provides the configural invariance structure. The fit indexes are at the acceptable level. If the configural invariance structure is provided, it is pointed out that students adopt the same conceptual perspective for the science self-efficacy in Singapore, Spain, and Turkey. The metric invariance is also provided between the countries. Metric invariance is achieved when different groups respond in a similar way to the same item. This means that the strength of the relationship between item and structure is the same among groups. When metric invariance is achieved, the scores obtained from the items can be compared between groups, and the variation observed in items may indicate differentiation between the groups in terms of the measured structure (Milfont & Fischer, 2010). As a result of the study, it can be said that the relationships between the characteristics of the scale items and the self-efficacy structure are similar for the countries. It is generally seen as satisfactory when the configured invariance is met (Sholz et al. 2002). The metric invariance is a prerequisite for testing scalar invariance analysis. The scalar invariance of the self-efficacy structure is not provided between the countries. Scalar invariance must be ensured to compare mean scores. The observed scores are related to the latent variable and individuals have the same score mean that they have the same score of structure regardless of group membership (Milfont & Fischer, 2010). If you do not have proof for scalar invariance, the latent structure cannot be compared among groups. Failure to provide scalar invariance also indicates that items can show bias relative to countries and in this case, it is not possible to make comparisons among countries (Steenkamp & Baumgartner, 1998). Students who are in the same population and are members of different groups may differ in their tendency to correctly answer a question or to endorse a category. This situation is associated with item bias (Yavuz, Dogan, Hambleton, & Yurtcu, 2018; Zumbo, 1999). When examining item properties, it is important to examine item bias depend on many different group characteristics (gender, language, socio-economic status, culture, etc.) (Millsap & Everson, 1993).

When the items listed in the self-efficacy scale are also reviewed, it is observed that the items are written by considering the natural events that may be encountered by the students in their life. For example, "Explain why earthquakes occur more frequently in some areas than in others" and etc. The context imposed by the student on the relevant event may differentiate by cultures, this can also lead to inter-group differentiation. The item properties must be discussed and the item bias must be reviewed in a separate study.

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How Do Theist (Muslim) Pre-Service Science Teachers Reconcile Their Individual Ontologies with Premises of Modern Science

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Abstract

The purpose of this study was to investigate how theist (Muslim) pre-service science teachers' reconcile their individual ontologies, which stem from their worldviews, with premises of modern science. 23 pre-service science teachers (10 males and 13 females, ages ranged from 19 to 23) were selected by purposeful sampling. Data sources included open-ended questions and semi-structured follow-up interviews. The qualitative analysis of data revealed that theist participants believing in a created Nature which is being lawful and understandable but also open to supernatural intervention diverged in their perspectives about the ontological premises that scientists must have and presupposed theism, theism/naturalism or just naturalism for doing science. They all asserted the physical universe as the boundary for science and evaluated the possibility of the scientific investigation of miracles and jinn within that boundary with the criterion of being able to obtain empirical data. They did not perceive any incompatibility between science and Islam and proposed methodological naturalism for scientific practice in order to overcome potential conflicts.

Introduction

Developing students' understandings of the nature of science (NOS) has been valued as an important aim of science education and the common aspects of NOS for the science education community are discussed in various documents (McComas, Clough & Almazroa 2000; Lederman, Abd-El-Khalick, Bell & Schwartz 2002). However, current discussions of the aspects of NOS are mainly based on epistemological and methodological issues. Basic ontological issues in regard to the subject matter of science in comparison with other ways of knowing (e.g. religion) are not explicitly being discussed in the science education community. Although there are some arguments, within the scope of NOS, about empirical and objective nature of the physical world that could be used to start a discussion about the nature of entities being investigated within the realm of science; such arguments are in need to be clarified for science educators. For this, science education community must focus on worldview studies which provide a theoretical foundation for ontological presuppositions of modern science. Hence, with that ontological basis, it would be more meaningful to reflect on epistemological and methodological issues of the NOS.

Worldview Studies

Worldviews are culturally organized macro-thoughts that provide dynamically inter-related presuppositions about the world (e.g. what it is really like, how can valid knowledge be derived). Worldviews also affect the individuals' decision-making processes as well as their conceptions of science (Kearney 1984; Cobern 1994). Related literature reports similar relationships between students' worldviews and their understandings of science (Allen & Crawley 1998), worldviews and epistemological beliefs (Tsai 2001), culture and perceptions about science (Sutherland & Dennick 2002). According to Liu & Lederman (2007) students may have alternative worldviews that are incompatible with science and teachers with more traditional worldviews may have inaccurate conceptions of the NOS.

A comprehensive understanding of the NOS (beyond having some declarative knowledge about it) means to understand science as a way of knowing and to be able to compare science with other ways of knowing. In this context, the issue must initially be based on ontological assumptions. However, the conflicts between worldviews (scientific, religious etc.) are mainly perceived as the differences in religious beliefs, moral values, socio-economic and political issues (Haack 2003). The on-going debate between evolutionists and divine creationists is a good example of such lack of recognition (Colburn & Henriques 2006).

Metaphysical views of knowledge vary along ontological assumptions regarding the definition of Nature and form of reality (Guba & Lincoln 1994; Uschold 1996), and epistemological beliefs dealing with the nature, sources of knowledge, and ways of knowing (Beeth & Kwak 2001; Çakır 2011; Snively & Williams 2008). Further, these assumptions and beliefs also vary between the knowledge systems (Aikenhead 2006; Dilworth 2006), the natural sciences (physics, chemistry, biology) and even the science topics within domains (classical/quantum mechanics, classical biology/ecology) (Dilworth 2006; Yore 2008). Therefore, the metaphysical core of modern science must be explicitly examined in order to understand science as a way of knowing and its boundaries.

Metaphysical Presuppositions

There is a variation of metaphysical views between indigenous, religious and scientific knowledge systems. The metaphysical assumptions are viewed as demarcating units to be examined in order to espouse the unique ontological and epistemological features of science as contrasted to others (Yore 2008). Modern science is assumed to be guided by the assumptions about the Universe; such as being knowable through rational/empirical means and eradicating mystery/spiritualism in favor of physical causality (Aikenhead 2006). It involves the notion of the cause-effect and mechanistic explanations which are mostly contrary to the basic assumptions of the indigenous ways of knowing. Matthews (2009a) stated that scientific inquiry of Nature presupposes certain metaphysical assumptions such as the existence of an external world which is independent of the observer, the universality of causation in that world, and the constancy (time-space) of causation. He also added an epistemological commitment, which is the opportunity of coming to know the external world, and an epistemic presupposition, which is the central role of evidence in deciding upon truth or falsity of a claim. Similarly, Cobern and Loving (2001) discussed the critical attribute of science as being naturalistic and labeled science as a material exploratory system which is objectively and empirically testable. Haack (2003) demarcated science from religion by stating that religion is a body of beliefs whereas science is a kind of inquiry. According to him, the core of religious worldview is the idea of a purposeful spiritual being that brought the universe into existence with a special place given to human beings and is concerned about how human beings behave and believe. This spiritual being is thought to be influenced by prayers and rituals. In addition, contrary to science, religions are asserted to be focused on absolute truths with supernatural explanations which are based on the authority of sacred text and faith (Yore & Knopp 2001).

Dilworth (2006) focused on basic ontological principles or presuppositions of modern science instead of epistemological and methodological ones. The rationale for his position was the relation of methodological and epistemological presuppositions with the ontological ones. For instance, the experimental method was supposed to give epistemologically valuable and replicable results because scientists assumed that Nature was ontologically uniform in a particular sense. The adoption of the experimental method itself was assumed to involve ontological presuppositions and it was asserted that in order to commit to a particular methodology, one must have a particular conception about the nature of the subject matter that is investigated. So, basic presuppositions (or principles) of modern science were taken to be ontological which were stated as general assumptions regarding the nature of the entities that modern science set itself to examine. Dilworth (2006) emphasized that presuppositions constituted the core (rather than the foundation) of the modern science and delineated an ontological paradigm or an ideal conception of the reality for scientists. The core presuppositions of the modern science highlighted by him were; (i) uniformity of Nature, (ii) principle of substance and (iii) principle of causality. The principle of the uniformity of Nature concerns a lawful natural change. This principle implies determinism but this determinism is not strictly required (e.g. probabilistic laws). The particular form of uniformity presupposition is that similar states of Nature are followed by similar states and location in homogenous space and time are not constituents of any state. The second presupposition, the principle of substance (or principle of the perpetuity of substance), is also related to the conception of change. It formulates change as alteration of the substance (material) which exists perpetually. In this context, it is assumed that no portion of substance either comes into or goes out of existence. The last presupposition, the principle of causality states that change is caused and restricts causes to natural entities, hence excludes supernatural causes from modern science.

Aim and Rationale of the Research

The literature on the NOS is mainly focused on various epistemological and methodological issues that are related to modern science. But, ontological assumptions in regard to the subject matter of science are not mentioned or discussed explicitly. The discussion of metaphysical assumptions or presuppositions (especially ontological ones) of different ways of knowing should not be left to small interest groups. This issue must be scrutinized within the science education community in a meaningful way in order to develop a qualified understanding of the NOS with a philosophical basis. The students in science courses should be informed about the presuppositions of various ways of knowing and hence be directed to question how reason operates in different disciplines (Cobern 2000a). Similarly, science educators should understand the consequences of such philosophical questions and their adopted answers about knowledge prevalent in the curriculum (Snively & Williams 2008). The first attempt in this approach should be to identify the current conceptions and basic assumptions of educators of science (and candidates) about the metaphysical core of the modern science as part of their worldviews.

The main purpose of this research was to investigate theist pre-service science teachers' perspectives of the compatibility of their worldviews with presuppositions of the modern science. In order to achieve this goal, the framework of steadily growing research on exploring the relationship between science and supernatural was adopted as the context of the study and the participants'; (i) individual impressions about Nature, (ii) ontological assumptions they assert for doing science, (iii) conceptions about the relationship between science and supernatural beings, and (iv) perceptions regarding the position of Islam originated knowledge claims in modern science were examined.

Method

The qualitative research approach (Creswell 2012) was adopted in order to reveal and interpret Turkish theist pre-service science teachers' perceptions of science and supernatural through their ontological assumptions about Nature. The participants of the study, the data sources, and the process of analysis are presented below.

Participants

The participants of the study were determined by purposeful sampling strategy within data collection process (Creswell 2012). The first criterion for selection was that the participants had not had any formal instruction about Philosophy and Nature of Science. The purpose of this criterion was to sample the participants who constructed their opinions about the relationship between science and supernatural within the context of their own cultural ecologies. The second selection criterion was that participants were theist, that is had belief in a personal God who is the creator of the universe and interacts with the universe as in the prayerful activities of humans (Smart & Haldane 1996), and were willing to explicitly express their individual worldviews in confidence. In order to implement these criteria for participant selection, the researcher developed open-ended questions that were administered to the class of 33 third grade pre-service science teachers at the first week of The Nature of Science and The History of Science course as a pre-instruction activity. Any material related to the content of open-ended questions was not presented to candidates until the data collection process ended. The compulsory course taught by the researcher for three hours a week was chosen to provide participants an authentic atmosphere in the scope of the research. All students enrolled in the course responded to the open-ended questions in written format individually and after initial analysis of the answers for their explicitness and persistence, 23 theist candidates (10 males and 13 females with ages ranged from 19 to 23) were identified as participants of the study. Participants who were not theists (4 deists, 2 atheists) and not willing to participate (4 theists) were excluded from the study.

Data Sources

Open-ended questions and semi-structured follow-up interviews were used to collect data (in a two-tier process). During the first step, the open-ended questions were used to collect preliminary information about participants' conceptions of Nature, science and supernatural. Then the semi-structured follow-up interviews which were based on the participants' responses of open-ended questions were conducted. The data collection process was performed as pre-instruction activities in the context of The Nature of Science and The History of Science course.

Open-Ended Questions

Participants' conceptions of presuppositions of the modern science in relation to supernatural were assessed primarily focusing on their ontological assumptions about Nature. The open-ended questions (see Appendix) used for that aim were designed in order to provide respondents with an opportunity to express their perspectives freely by widening any discussion in any context they deemed appropriate. They were developed and validated by the researcher in a previous study (Turgut 2011) about worldview issues such as beliefs about Nature, apriori assumptions in science, religious beliefs and science, comparability of science and religion, and adopted for this research.

The first open-ended question was aimed to elicit the participants' impressions about Nature (e.g. if Nature is eternal, lawful and open to supernatural intervention). Since the concept of Nature is quite profound and not easily addressed extemporaneously (Cobern 2000b), it was not simply asked as 'What is Nature?' Three mainstream approaches, namely theism, deism and materialism, were briefly summarized before asking participants to write and discuss their perceptions about Nature. Therefore, in the first question participants wrote down and clarified their individual perspectives in relation to those mainstream views, or any others they perceived that reflects their opinions. The second open-ended question focused on their perceptions of the presuppositions of scientists while doing science. The participants were asked to compare their individual assumptions of Nature with the ones that were presupposed by the scientists. The remaining four questions were about the relationship between science and supernatural (such as the Allah, miracles, and jinn), science and Islam originated knowledge claims, and science and faith. Therefore, the overall purpose of the open-ended questionnaire was to elicit and clarify participants' perspectives of science in relation to supernatural (Islam) on the basis of their individual ontologies. The intention of each open ended-question is summarized below in table1.

Table 1. Open-ended questions and their intends

Question	Intend
Q1	Perceptions about Nature
Q2	Perspectives regarding presuppositions of scientists about Nature while doing science
Q3	Perceptions about relationship between science and supernatural
Q4	Perceptions about boundaries of science and examination of supernatural (miracles, jinn)
Q5	Perceptions about scientific investigation of religious propositions regarding physical entities.
Q6	Perceptions about the role of faith in scientific practice.

Although each open-ended question aimed to elucidate a certain aspect of the participants' perspectives, they were transitive in that they directed participants to ponder about science, supernatural and their relation in various contexts as a whole. The open-ended questions were designed to stimulate participants' reflections and thinking about the concepts they used. Their answers to different questions allowed the researcher to evaluate the consistency of individual answers. Participants answered the questions in written format in approximately 40-50 minutes. They were asked to support all their answers by providing an explicit rationale. In order to encourage participants to share their actual opinions, rather than what they believe is acceptable, they were asked to use nicknames or symbols in their answer sheets instead of their real names.

Follow-Up Interviews

Initially, participants' responses to the open-ended questions were analyzed by the researcher. During document analysis, the participants' responses were carefully coded and follow up questions were developed for the interviews. Hence, the contents of the semi-structured follow-up interviews were individually crafted for each participant. Such an approach enabled the researcher to perform in-depth analysis of each participant's conceptual framework. Moreover, participants' points of view were probed and investigated for the meaning and understanding attached to their individual experiences (Kvale & Brinkmann 2009). Once the semi-structured interview protocols were ready, the schedule for the interviews was announced in class, with reference to nicknames. Participants who felt uncomfortable to verbally participate in an interview were allowed to respond the interview questions in written format. This was a crucial and necessary measure because of cultural and social pressures that some of the participants may have felt. They may have felt uncomfortable to share their worldviews with the instructor worrying about being labeled as religious or vice versa. The majority of the participants (8 females and 7 males) gave their consent for face to face follow-up interviews that were conducted on campus in the office of the researcher.

The follow-up interviews started with providing participants with their own answer sheets to open-ended questions. Then the researcher's notes and follow-up probing questions were provided to them for further clarification and elaboration of the responses. The interview process was flexibly designed allowing the researcher to ask prepared questions that covered the related topics, as well as to explore the issues emerging during the interview (King & Horrocks 2010). For instance, a participant who responded to the open-ended question as 'Jinn can be subject of science... Jinn is a nonphysical being and cannot be examined…' was asked to explain how he/she thought that a nonphysical being could be subject of science. Similar conversations were carried out in order to understand the participant's conception without any sign of judgment or sense of inconsistency. Each interview lasted approximately 20-30 minutes.

A similar procedure was followed for the participants who did not prefer to participate in face to face interviews. The answers these participants provided to the open-ended questions were reviewed and re-circulated to them in class using their nicknames. For each of their answers that were found to be confusing or open to misinterpretation, the researcher posed new questions or requested explanations in comment boxes, and participants were asked to respond to them in an additional answer sheet. The participants completed this task in 20-30 minutes and returned their responses to the researcher.

Data Analysis

In the first step of the data analysis, a data set was formed for each participant (including the answer sheet of open-ended questions and interview document/additional answer sheet) and was labeled (e.g. PST1; PST1 stands for Pre-Service Science Teacher One). Then, an initial superficial examination of the data was performed for each participant's data set to see if any possible misinterpretation or inconsistency still existed either for respondent or researcher. At the end of this stage, it was concluded that data collection process could end. Afterwards, actual data analysis was conducted comparatively within each participant's data set.

During the analysis process, interview documents or additional answer sheets were integrated with responses to open-ended questions to facilitate the examination of data set. The responses from those documents were compiled with the related responses to open-ended questions. Each participant's data set was treated as an uninterrupted text and their responses were viewed holistically since the open-ended questions were transitive. It was observed that participants sometimes responded to a question by referring to another one and performed a multifaceted approach.

After the organization of data for actual analysis, the data set for each participant was considered separately before searching patterns across the whole group since the research had an idiographic nature and comprised complex individual thinking (Taber, Billingsley, Riga & Newdick 2011). In this process, each participant's written responses and interview documents were read comparatively and any bit of information stated by a word, sentence or whole paragraph was labeled and coded to establish the initial list of codes. With the help of those codes, the participants' individual positions were further clarified and evaluated in order to resolve any purported contradiction that was not considered earlier. For instance, a participant had expressed that he/she is against restricting science and then indicated that jinn cannot be investigated scientifically since any empirical evidence could not be obtained. That participant's list of codes was re-examined as a whole (including the ones related with miracles, Supreme Being etc.) and then it was considered that in fact he/she restricted the subject matter of science to physical entities.

In the second phase of the analysis, the initial codes which were developed for each participant were reviewed and through constant comparative method similar and related codes were combined to form more general categories (Gay, Mills & Airasian 2006; Bogden & Biklen 2007). The same process was repeated for the whole study group in order to develop the final list of codes. A brief sample of final codes developed for participants' positions with regard to the presuppositions of scientists' about Nature is presented in table 2.

Table 2. Sample position and related codes

Position	Codes
Scientists presuppose Theism	Faith in Allah as the major cause
	Faith in Allah as the motivator
	Faith in Allah as the source of order

In third and final phase of the analysis, the final codes were scrutinized for their power of representation by reviewing the participants' data sets which also enabled the researcher to determine the frequencies of those codes across data. When it was decided that the final codes represented the data adequately, participants were categorized according to their positions and the analysis process was ended.

Results

The main proposition of theist participants of this study was that Nature operates lawfully as a system with the laws/principles set by Allah. However, they also believed that Nature is open to supernatural intervention. They accepted some exceptional cases, also called miracles, within lawful Nature. Miracles are events reported in divine texts and in history of the religion, in this case Islam, in which the laws of Nature are distorted. Theist participants were mostly impressed by and admired the laws of Nature and the beauty of the creation of Nature. According to them science is an endeavor for discovering the laws of Nature in order to understand how Allah acts. However, participants proposed three different orientations when they were asked about the presuppositions of scientists about Nature while doing science. These orientations were (i) theism, (ii) theism and/or naturalism and (iii) naturalism. The branching proceeded in relation to the issues of science, supernatural and the relation between them.

Group 1: Theist Participants That Assumed Scientists Presuppose Theism

A group of theist participants (10 out of 23) assumed that scientists presuppose theist conception of Nature in their scientific research. They adopted such a perspective in line with their individual ontologies and although had indicated that science is restricted to physical universe (Nature), they all tried to make room for Allah in the scientific discourse as the creator and source of the order in the universe. Their stances comprising presuppositions of modern science and supernatural entities are outlined in figure 1.

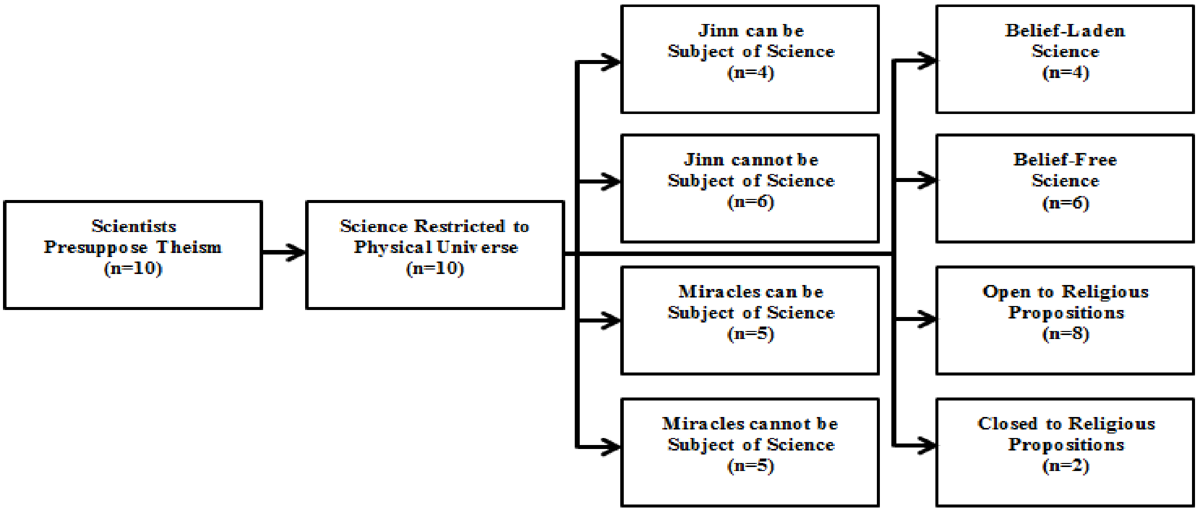

Figure 1. Stances of theist participants who assumed theism in science

While asserting a theist assumption of Nature by scientists, the basic notion of these participants was that the scientists' motivation for inquiring into order in the universe was to appreciate the art of Allah. Within this perspective Allah is the major cause of everything in the universe and faith in Allah was presented as the meaning of life.

> Scientists search for the laws and this means order. So doing science requires accepting that there is a knowable order in Nature. We know that a system with an order cannot survive without a regulator. I believe that Allah created the universe, set the rules and let the system work by itself. Believing in Allah empowers the scientist, provides him with the real meaning of life and motivates him to conduct research for understanding Nature that is created by Allah. Science does not require rejecting Allah (PST 6).

When they were asked about how to cite Allah in scientific research which is restricted to the physical universe, the participants indicated that the Supreme Being is a meta-concept for scientists and cannot be included in any equation. Rather, they claimed that scientists can accept the existence of Allah and aim to determine the physical principles of the universe set by Allah. Hence, they asserted that scientists can try to understand the creation while being restricted to work in the physical universe.

> Allah cannot be cited in any physical equation of course or we cannot explain a phenomenon by only Allah's wish if we are doing science. Science is only about physical beings. But the point is that I can be a scientist believing in Allah who created a lawful universe and try to understand this creation by conducting science. In this case, scientific research will mean devotion (PST 10).

According to this group of participants, the idea of Allah cannot be asserted as an explicit explanation in any scientific discourse but provided a motivating factor for scientists in their research as the implicit major cause of everything. They believed that with such an assumption scientists perform an act of devotion while performing science. Those participants attempted to clarify the issue by stating the acceptance of Allah as a matter of belief operating in the background of scientists' thought system. So, they tried to overcome the purported contradiction that scientists can presuppose theism while operating just in the physical universe.

The majority of those theist participants (8 out of 10) indicated that religious texts and especially Holy Qur'an can be considered as a source of knowledge in regard to some aspects of Nature. They claimed that scientists should be open to Islamic propositions about the physical universe and perform research based on those propositions.

> In the case of being open to empirical investigation, testing, and argumentation, scientists should examine propositions written in religious texts. But this is not possible for supernatural issues. We know that Holy Qur'an includes knowledge about the physical universe and its laws such as expansion of the universe, the origin of iron on Earth. There are many other examples (PST 14).

The participants asserted that the Holy Qur'an provides knowledge about the laws and structure of the universe and they presented examples as the ones presented above. Although none of those participants could exemplify the issue by directly citing verses from the Holy Qur'an, it was tangible that this assertion was so accurate for them. The criterion they set for the issue was being a physical phenomenon which was seen to be consistent with their assumption that science is restricted to the physical universe.

The issues of miracles and supernatural entities (such as jinn) were also questioned in regards their potential as subject matter for science, in conjunction with being open to religious knowledge claims in science. For some participants this was possible and plausible; however for some others it was not possible or plausible. When they were asked to justify their positions about the scientific inquiry of miracles and jinn, they set the condition of having direct or indirect tracks/signs in the physical universe which can be investigated.

> Miracles can be subject of research that scientists investigate. As written in Holy Qur'an, they are real and occurred in the physical universe. Some of them can be explained if relevant data is obtained. If a miracle cannot be explained by the physical rules and scientific knowledge available at a time, scientists must be fair and say "it was a miracle". But jinn cannot be investigated. They are supernatural entities (PST 21).

> I believe that miracles occurred historically. But they are "miracles" and hence are out of the usual order and physical laws. They cannot be examined scientifically. Why do we need to explain them scientifically? It is same for jinn (PST 10).

> Not miracles but jinn can be investigated as a form of energy or field. I do not know how but in the future, as tools and methods of science will be developed, the subjects that seem to be out of science will be investigated by scientists (PST 8).

As seen in the quotations presented above, the responses of the participants were not so homogeneous for topics of miracles and jinn. Some of them accepted the possibility of the scientific investigation of both miracles and jinn; some of them rejected both. Some of them accepted miracles but rejected that jinn could be investigated scientifically and vice versa. They were consistent in their claim that science is restricted to the physical universe and any process or being must yield empirical data to be investigated scientifically.

Based upon the arguments that Allah can be cited in science as the major cause of everything in the universe and scientists can examine the Islamic knowledge claims about Nature, theist participants were also asked to argue the role of beliefs in science. The question related to whether the research of atheist and theist scientists could be reconciled. The group was divided into two on this issue. Six of them indicated that since their subject matter is the physical universe they will reach the same results whereas four of them asserted that their conclusions will be different.

> There would not be any differences. Scientists work on objective, empirical entities and they would not wear religious clothes while conducting science. Theist believes in Allah, atheist rejects Creator but then theist will not cite Allah in any explanation. They will reach the same physical laws. The only difference would be the interpretation of major cause (PST 11).

> An atheist rejects the existence of Supreme Being and this affects his/her perspective and interpretation of the research. The same is also true for a theist. Two scientists with different belief systems will work in the light of their assumptions and hence should arrive at different conclusions (PST 3).

The participants who purported that atheist and theist scientists will reconcile used the motive of objective and empirical nature of entities being investigated while conducting research. Their claim was seen to be restricted to the visible side of scientists' conclusions such as formulated physical principles and laws. Indeed, they implicitly claimed that atheist and theist scientists will differ in the meaning they attributed to the universe; if it operates by itself or if the Supreme Being intervenes in it. On the other hand, the notion of belief-laden science and hence possible differences in atheist and theist scientists' research were explicit in the rest of the group.

Group 2: Theist Participants That Assumed Scientists Presuppose Naturalism/Theism

A group of theist participants (10 out of 23) assumed that scientists could presuppose either theist or naturalist conceptions of Nature while conducting scientific research. These participants did not consider any functional differences between those two radically discrete worldviews (theism/naturalism) but some of them gave priority to theism in performing science. Their claims for the issues raised in this research are not mentioned in detail here since they were so similar to those in Group 1. This section is focused on the rationale of theist participants who were open to naturalism in science. Their stances comprising presuppositions of modern science and supernatural entities are outlined in figure 2.

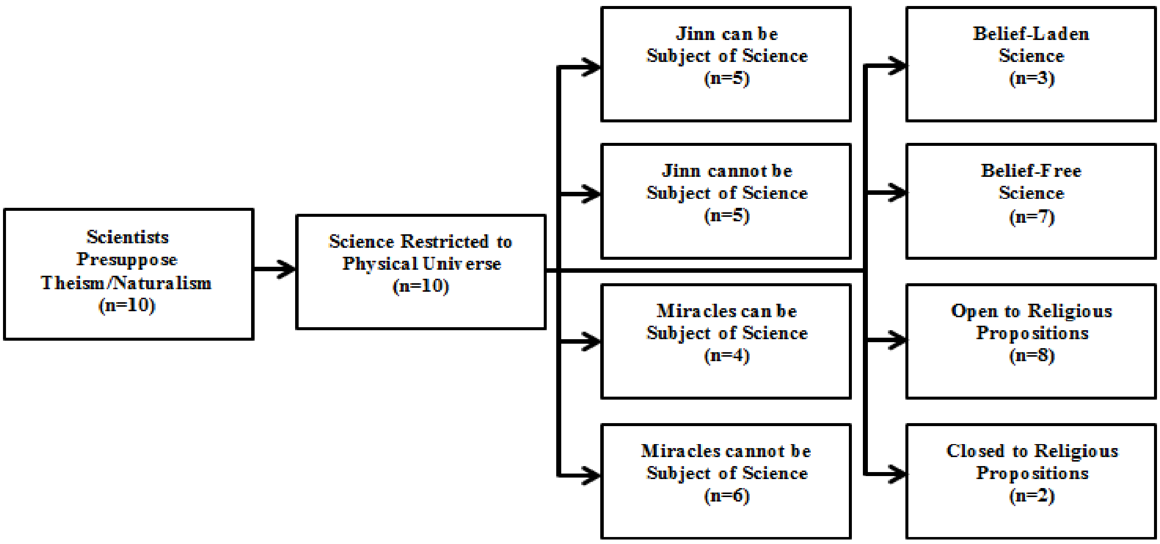

Figure 2. Stances of theist participants assuming naturalism/theism in science

Theist participants of this group believed in a created Nature which operates according to the laws set by Allah. In addition, they asserted that Nature is open to supernatural intervention. As was the case for Group 1, all stated that the practice of science is restricted to physical universe (Nature). The majority of them accepted the inclusion of the idea of Allah as a meta-concept in the scientific discourse as the creator and source of the order governed in the universe. In contrast to the first group of theists, these participants were also open to a naturalist conception of Nature to some degree in doing science.

> Scientists can operate under both naturalist and theist prepositions. They all say that Nature is lawful, working under principles set by Allah. Science is regarded as the laws, order, and principles. The only

> difference may be the acceptance of Allah. This is out of science; belief. So either naturalist or theist they will arrive to the same conclusions (PST 7).
>
> Both can be. But in fact, theist scientists will provide more meaningful conclusions with real explanations. Naturalists will have some disadvantages and restricted with the concept of “chance” while theists will load meaning to Nature and know that Allah is the major cause. Anyway, they will find same physical laws (PST 13).

Participants in this group were divided into two categories according to their assertions. Half of them gave priority to a theist conception of Nature while the other half did not see any apparent functional difference between naturalism and theism for scientists in doing science. The common rationale for both categories was the order and lawful operation of Nature. Hence participants claimed that scientists have to reconcile their physical explanation of Nature and its principles with their metaphysical presuppositions about Nature.

Participants who assumed that scientists can have both naturalist and theist presuppositions of Nature stated similar arguments for the issues as other theists in this study such as the individual conception of Allah as the major cause, the position of religious texts and Holy Qur’an as a source of propositions about Nature, the scientific investigation of miracles/jinn and the role of the beliefs in science. The majority of them (7 out of 10) indicated that the idea of Allah cannot be cited directly in scientific texts but can play a role in the personal thought system of the scientist in relation to the big questions about meaning of life.

The position of religious texts and Holy Qur’an as a source of knowledge claims about Nature was also evaluated positively by the majority (8 out of 10) with the requirement of being open to empirical investigation. They believed in the existence of miracles and jinn referencing the Holy Qur’an. Participants’ opinions were divided about whether these conceptions can be investigated scientifically, with some supporting and others rejecting this notion, but all indicated the importance of collecting empirical data for such an investigation. Finally, as was the case for Group 1, the majority of participants (7 out of 10) in this group interpreted the issue of the role of beliefs in science for atheist and theist scientists, concluding that they could reconcile any differences because of the objective/empirical nature of the entities being investigated.

Group 3: Theist Participants That Assumed Scientists Presuppose Naturalism

A small portion of theist participants (3 out of 23) indicated that scientists must embrace naturalist prepositions in order to conduct scientific research. They asserted that science as a way of knowing has its own worldview and scientists must adopt it in order to operate in the milieu of science. Their stances about presuppositions of modern science and supernatural entities are outlined in figure 3.

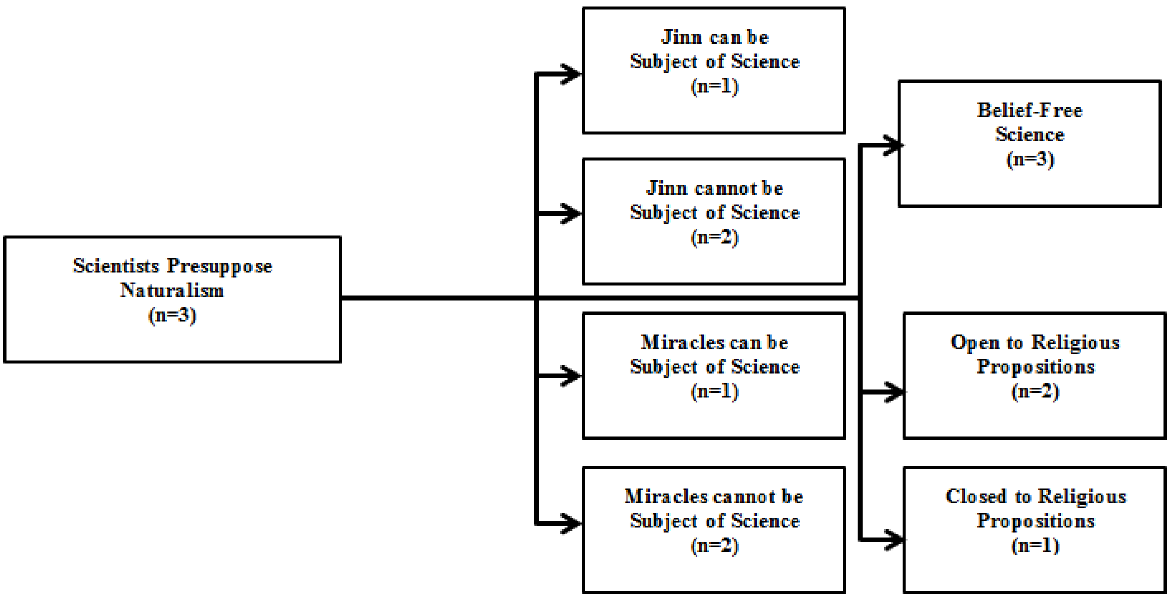

Figure 3. Stances of theist participants assuming naturalism in science

While Group 3 participants also believed in a created and lawful Nature, they also claimed that in order to conduct scientific research one needs to put aside that faith and wear the naturalist lab coat. They stated that scientists must assume a mechanical Nature working as a machine by itself, in spite of their individual worldviews which might state otherwise.

> For doing science, all scientists must have consensus on their conceptions of Nature. This must be independent of their beliefs. Science presupposes a mechanic Nature I think. It is a machine that is self-working according to pre-determined rules. I can do science in this context while I am theist (PST 2).

> A scientist must presuppose a lawful Nature operating just like a machine. Any supernatural reference should not be made. In order to build a consensus with all the other scientists he/she has to work independent of individual beliefs, either atheist or theist (PST 23).

Group 3 participants restricted the subject matter of science to physical entities and excluded the concept of Supreme Being totally from science even as a meta-concept. By doing this, they tried to establish a common ground for all scientists with various worldviews, based on physical phenomena alone. In addition, they rejected any attempt to confirm the existence of the Supreme Being since it is an issue of faith for them. This understanding aligned with their position regarding whether or not a scientist can include the acts of Allah in science.

> We cannot cite Allah in science. Science is only about physical beings. In fact belief in Allah does not require any reference from Nature for me. I believe in and that is all. While doing science I try to understand only the principles and laws of Nature. Supernatural is out of science and for this reason, science is for all including also who do not believe (PST 18).

According to these three participants, the idea of Allah can neither be asserted as an explicit explanation in any scientific enterprise nor be governed as an implicit meta-concept as a matter of belief operating in the background of scientists' thought. So they indicated that science is blind to any element of faith regarded with supernatural and established a common ground for scientists who are either atheist or theist.

On the other hand, the participants differed in their views when they considered the issue relating to religious propositions, miracles, and jinn.. For instance, two of the participants purported that the verses of Holy Qur'an should be considered as a source of knowledge claims in science with regard to natural phenomena. They asserted that all propositions would be examined for empirical verification in the context of science if possible and the source would not be evaluated with bias.

> Some propositions from religious texts and Holy Qur'an can be subject to science if they are open to empirical testing. The rules for science and scientific research are obvious. Any proposition from any source would be investigated if they are in the scope (PST 23).

In fact, all the participants in this group were open to empirically testable propositions from all sources. As seen in the quotation given above, their major motive was being in the scope of science as a subject matter to be investigated. While two of the participants did not reject the inclusion of propositions presented in the religious texts with regard to natural phenomena, the third participant disagreed, noting that religious texts are generally different in nature from scientific ones, and hence should be excluded.

Based upon the participants' thinking about whether religious texts could be a source of knowledge claims, the researcher questioned them further about miracles and jinn in order to understand their points of view more deeply. They were asked to justify their positions and it was identified that their major reason for accepting or rejecting miracles/jinn as the subject matter of science was being open to empirical investigation.

> As we believe, miracles had occurred physically in Nature. So the point is if we can find empirical data in Nature about them. The same is valid for also jinn. Jinn cannot be examined scientifically since they are supernatural. Can we have a jinn or any sign about it to investigate empirically? I do not think (PST 2).

> Neither miracles nor jinn can be investigated scientifically. Firstly miracles are exceptional events. They did not obey the rules of mechanic Nature. Science is interested in laws but not in exceptions. Jinn is out of the physical universe and hence supernatural. They cannot be examined (PST 18).

While the responses of the Group 3 participants differed in relation to either accepting or rejecting the possibility of investigating miracles and jinn scientifically, they provided similar reasons. Their opinions were consistent with their previous claims regarding a mechanical Nature as the basic assumption of science, maintaining the scope of lawful Nature and requirement of yielding empirical data.

Discussion

Participants of the study expressed their belief in a created Nature which is lawful and understandable. They supported the assumption of being lawful with the premise of empirical investigation of natural causes in accordance with the proposed pillars of modern science (Hocaoglu 1996; Aikenhead 2006; Matthews 2009a). On the other hand, they also asserted that Nature is open to supernatural intervention in the form of miracles. They labeled miracles as exceptional cases that do not rule out the lawful operation of Nature. As has been reported previously (Kearney 1984; Cobern 1994; Allen & Crawley 1998; Tsai, 2001; Sutherland & Dennick 2002; Liu & Lederman 2007; Çakır 2008; Mansour 2011), participants' individual ontologies determined their conceptions of science and the presuppositions they assumed for scientists in order to conduct science. The great majority of theist participants (20 out of 23) asserted that scientists can behave as theists while conducting science although an important portion of them (10 out of 23) were also open to naturalism. However, a small portion of theist participants (3 out of 23) assumed science as a distinct culture and presupposed just naturalism for scientists apart from their individual ontologies.

All of the participants, as theists, had declared their belief in Allah, the verses of Holy Qur'an, miracles and jinn. Apart from those proposing just naturalism for science, theist participants predominantly asserted that Allah would be considered as a meta-concept in scientific enterprise that motivates scientists in their work. Their approach was an attempt to reconcile their individual ontologies with the practice of science. They claimed Islamic Science (Loo 2001; Mansour 2011) comprising some religious motives in the research of Nature, but adopted the methodology of Western Science, namely methodological naturalism (Irzik & Nola 2009). Theist participants could be viewed as having adapted to the culture of modern science, since as Matthews (2009b) argued, methodological naturalism does not disregard religious cases (e.g. miracles or Divine interventions) but means that such processes cannot be appealed to whilst seeking scientific explanations. Their tendency was to stand in the milieu of modern science without losing the meaning they individually held about it. Such a position evoked the criticism of Cobern (2000a) about the radical empiricist worldview which is often associated with modern science for eroding society's meaningful sense of life.

The participants asserted the physical universe as the boundary for science and evaluated the possibility of the scientific investigation of miracles and jinn within that boundary. They all declared their belief in miracles/jinn and answered the issue of whether miracles/jinn can be the subject of science either positively or negatively, but maintaining their commitment to the need to be able to obtain empirical data through methodological naturalist approach (Eastwell 2011; Fishman 2009). Their stance was in accordance with the widely accepted scientific attitude and premises of modern science (Gauch 2006; Cobern & Loving 2001). The participants' positions about the role of beliefs in scientists' work were also partially based on the methodological naturalist approach and the boundary they established for science. Some of the participants (7 out of 23) indicated a belief-laden scientific practice. On the other hand, the remaining participants (16 out of 23) viewed science as being blind to any element of faith. The participants who proposed belief-laden scientific practice focused on religious beliefs and indicated that scientists should diverge in the interpretation of data because of their religious beliefs (Lederman 2004; Lederman, Abd-El-Khalick & Akerson 2000; Lederman, Abd-El-Khalick, Bell & Schwartz 2002). They asserted that theist scientists have answers to existentialist questions in advance provided to them by Islam. On the other hand, the great majority of participants (16 out of 23) proposed a belief-free approach to science. They indicated that in order to understand Nature, scientists conduct research in an objective and empirical manner; therefore they should inevitably conclude the same physical laws. They totally ignored the role of paradigms, beliefs and individual philosophies in the construction of knowledge and proposed a belief-blind mechanical process (Cobern 2000a; Akerson, Abd-El-Khalick & Lederman 2000).

The participants' opinions about Islamic propositions comprising natural entities/processes, namely the physical universe, were also coherent with their assumptions of the role of beliefs in science and the ontological presuppositions they asserted for scientists. The majority of participants had purported that Holy Qur'an would be considered as a source of knowledge claims by scientists (Mansour 2011). For them science is open to all kind of knowledge sources and hence to religious texts. They labeled any bias in this context as being restrictive but that did not mean they were unconditional. They stuck to the boundary they set for science as being open to empirical testing and being in the scope of Nature as discussed by Fishman (2009) and Eastwell (2011).

Conclusion

Before reaching a conclusion, it must be explicitly mentioned that results of this research cannot be extended directly to wider populations because of the nature of qualitative approach preferred. So, the results and conclusion can be thought as valid for just the groups having similar qualities with the study group.

The results of the study implied that although theist participants believed in a created Nature that is open to the intervention of Allah, they did not deny the principles of causality and lawfulness in the operation of physical processes in general. They consider miracles as exceptional phenomena. Therefore, their faith in miracles did not corrupt their perceptions regarding those basic assumptions of modern science. A participant who believes in miracles does not refute, therefore, that Nature behaves orderly according to the physical laws. On the other hand, participants diverged in their conceptions of the ontological basis of modern science. While majority of them asserted that scientists can perform research with either a theist or naturalist view, some participants proposed that they only held onto a naturalist view which may contradict their personal ontologies. Such a position indicated that not all of the theist participants feel obliged to reconcile their individual ontologies with the modern science. They perceived science as a discrete intellectual activity, appreciated it and did not consider the exclusion of theism from science as a cause of crisis.

Although the participants' declared that they strongly believe in miracles and jinn, they depended on the possibility of having either direct or indirect empirical data in scientific investigation of those supernatural entities. They did not tend to construct their faith on the findings of science and hence were not inclined to push the limits of science (e.g. distorting the methodology of science towards pseudo-scientific contexts) in order to support their belief in supernatural. In fact, they were not conditioned to confirm their theistic views with scientific research. The participants' respect for the methodology of science was also considered in the case of knowledge claims that originated in Islam. They consistently asserted that those claims should be noticed if it is possible to obtain related empirical data and did not absolutely separate knowledge claims as religious or scientific. The participants instead focused on whether these claims have potential of being empirically testable in order to be in the scope of the modern science.

Overall, participants engaged in rich conversations regarding causality, lawfulness and empirical processes while arguing ontological basis of science and supernatural. An absolute conflict or integration perspective for science and theism was not explicitly determined in their statements. While they maintained a strong theistic faith that also partially shaped their conception of science (e.g. motivation role), they were simultaneously ready to respect the methodology of science in the case of any scientific discourse (methodological naturalism).

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Appendix

Open-Ended Questions

1) Identify your individual perspective about "Nature" please. For instance;
a) Nature is a mechanic system operating itself according to constant laws. We do not need any "Supreme Being" in order to explain this system. The laws which are determinant in the operation of "Nature" did not change over time and also will not in the future; mystical and miraculous events are not possible.
b) Nature is created by "Allah" as a system operating by determined principles and dedicated for the benefit of human being. Allah can manipulate the principles (laws) of the system; particular effects should not cause particular results all the time (miracles). We can infer about the existence and absolute power of Allah by examining the created "Nature".
c) Nature is created by a "Supreme Being" as a system operating by determined principles and dedicated for the benefit of human being. After the creation, "Supreme Being" did not intervene "Nature" and let the system operating itself. Human being can infer about the existence and absolute power of this "Supreme Being" by examining the created "Nature".
d) Please mention if you have any other views…

2) Does "Modern Science" presuppose any particular perspective of "Nature"? If yes, identify that perspective and compare it with your individual perspective of "Nature".

3) Do you think a scientist should cite "Allah" in any part of modern science?

4) Can we talk about the boundaries of "Modern Science"? Can there be any subject areas that "Modern Science" would not be dealt with? For instance do you think the propositions about "jinn" and "miracle" would be examined scientifically?

5) Can some propositions presented in religious texts and Holy Qur'an with regard to physical entities or nature be subject of modern science? Can scientists investigate them scientifically?

6) Will there be any differences between the scientific works of theist (Muslim) and atheist scientists? If yes, please identify what type of differences would be at which stages of their work?

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Education for Sustainable Development in Primary School: Improvement of Students' Ecocriticism Skills

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Abstract

Ecocriticism analyzes the symbolic meanings attributed to nature and the mindsets created by these meanings through interpreting literature and cultural texts from an environmental perspective. The individuals who have gained ecocriticism skills are expected to create an awareness concerning possession of a distinctive value and to direct towards a non-anthropocentric understanding from an anthropocentric understanding. The purpose of this study is to develop ecocriticism skills of primary school students in the third grade. Action research design has been used in this study. A total of 15 students composed of 8 females and 7 males participated in the study. Data of the study were obtained with rhetorical discussion, analytical discussion, mind maps, and drawings. Following the implementations composed of discussions, mind maps and drawings, it has been determined that the implementations develop the ecocritical inquiry skills of students.

Introduction

The fact that the struggle to dominate nature has reached to an uncontrolled dimension has caused a disruption in the harmony of people with the environment they live (Özenoğlu Kiremit, 2013). The mismatch between the environment created by the human will and the natural environment has revealed environmental problems (Güngör, 2015). Just like other branches of science, the fields of art and literature couldn't keep silent for the destruction of nature; an awareness for nature was attempted to be created with such texts as poems, stories, and novels (Bayraktar, 2015). Addressing the relationship between the environment featured by ecological researches and humans being a part of it within the context of literature has created the concept of ecocriticism (Solak, 2012).

Ecocriticism analyzes the symbolic meanings attributed to nature and the mindsets created by these meanings through interpreting literature and cultural texts from an environmental perspective. It critically addresses the problems related to the environment and value judgements in the content of the text and creates an interdisciplinary field of study (Oppermann, 2012). While ecocriticism has focused on romantic period poems, wild narrative stories, and nature literature at first, it has tended towards the different dimensions of cultural field in recent years and analyzes such fields as scientific literature, film, television, art, architecture, zoos and shopping centers (Garrard, 2004). Ecocriticism, that has started to be accepted since 1990 as criticism theory and academic discipline analyzing nature in cultural works, brings literary criticism and ecology together (Güngör, 2013). According to ecocriticism perspective, literature has been shaped with the sociocultural, political and economic structure of the society and it should create its own discourse against today's environmental problems. As stated by ecocriticism understanding, literature which is highly effective in creating and changing the human's thought systems will contribute to the solution of environmental problems by undertaking a social responsibility role (Bulut Sarıkaya, 2012).

Ecocriticism analysis seeks answers for the following questions while addressing an ecological problem:

> How is nature described in the text? What is the role of place in the plot? Are the values in the text compatible with the ecological virtues? How did the concept of wildlife change in time? How are the environmental crises reflected in today's literature and popular cult and what is its effect? What is the effect of ecology science on literary works? In what way and how much are the scientific studies open to literary analyses? How will the interaction between literary studies and environmental discourses and such disciplines as history, psychology, art history and ethics be ensured? (Glotfelty, 1996; Wang, 2009; cited by Arıkan, 2011).

The ecocritical perspective shaped within the framework of these questions makes the inquiry activity directed to the content multidimensional from economic, ethical, philosophical and psychological aspects.

The publications and reports revealing the dimension of the damage given to ecosystem scientifically are observed to be not so effective in raising awareness for the ecological problems. The fact that literary narrative affects human beings by directly reaching their consciousness contributes people more to understand the inherent value of nature. This situation helps ecocriticism speak to a wider area and be more effective (Oppermann, 2009). Literary works allow children and young people to better organize their lives with their real or reality-like fictions and they provide the opportunity to see what is right or wrong in life (Arıcı, Ungan & Şimşek, 2014).

Education for Sustainable Development and Ecocriticism

Sustainability expresses a paradigm based on the understanding of improving the quality of life and ensuring development with a concern for the future in which economic, social and environmental dimensions are balanced. The sense of life prioritizing economic development only features the pragmatic outcomes of social and environmental developments. The sense of life adopting the sustainability paradigm accepts that not only the outcomes of human's welfare and economic development but also the serious threats directed to the environment should be addressed. Sustainability is a long-term target and many processes and methods to reach this target are explained with the concept of sustainable development (UNESCO, 2012). Sustainable development is defined as meeting the needs of today's individuals without hindering future generations from meeting their own demands (Brundtland Report, 1987).

Raising the awareness of sustainability and sustainable development with its economic, social and environmental dimensions falls into the fields of interests of many disciplines and sub-disciplines. In the last thirty years all around the world, global awareness has been attempted to be ensured with the meetings held by such global organizations as European Union (EU) and United Nations (UN) directed to sustainable development and the countries have been laid various burdens. In the UN General Assembly held in 2000, nearly 60 targets including such topics as peace, development, human rights, and environment were set. The subjects of increasing efficiency by changing the lifestyle in economic sense, being more careful about the use of energy and natural resources, using clean production technologies that will reduce the use of resources, improving the unbalanced distribution of income and health conditions and securing the justice in access to education and social services are some of these targets. European Council published a report in 2006 which included the renewed and improved sustainable development solutions for European Union countries. This report stipulates that long-term and effective strategies with which the European Union will ensure sustainable development can be improved through finding a unique and integrated solution. In this strategy with its main aim expressed as "Defining and improving the actions that will provide the increase in quality of life of both today's generation and future generations", there are long-term targets, aims and concrete steps for seven basic priorities (Council of the European Union, 2006). These are stated as climate change and clean energy, sustainable transportation, sustainable production and consumption, a threat of public health, protection and management of natural resources, social integration, population, and immigration and struggle against global hunger (Tanrıverdi, 2009).

The solution of global problems is rendered with sustainable development practices and governments, society and individuals are assumed responsibility for sustainable development. Education is an important tool in order to improve the perceptions of public opinion about environmental science and policies, to protect natural resources, to define environmental problems and to create sustainable lifestyles. Education for Sustainable Development (ESD) aims to raise responsible and environmentally literate individuals regarding adoption of use of sustainable resources and solution of global environmental problems (Hungerford & Peyton, 1976; Roth, 1992). In this sense, individuals should receive education for an environmentally, socially and economically sustainable world. This education should adopt a multidimensional and dynamic approach composed of different tools, methods and various ideas based on problem-solving rather than uniform methods. This study is based on the assumption that ecocriticism being a criticism method which addresses environment and environmental problems over a general or special condition can be used within the context of ESD.

In today's world, children are always in interaction with lingual and audiovisual stimuli (animation movies, songs, toys, computer games etc.) (Hayran, 2010). Interpretation occurs when these stimuli find a response in the cognitive and affective world of children. It is assumed that the awareness of individuals who can approach these stimuli from the ecocritical perspective as of early ages and the meanings they have attached to the ecological elements can be developed. It is observed in literature that the studies conducted in the field of ecocriticism are at the corporate level or various works are analyzed in ecocritical dimensions (Balık, 2013; Bayraktar, 2015; Cengiz, 2013; Güngör,2015; Güngör, 2013; Islam, 2018; Parlak Temel, 2010; Solak, 2012; Toska, 2009; Wang, 2018). The studies addressing the activities of students regarding the possession of such skills by carrying the ecocriticism to the learning environments aren't observed. The criticism of children on the materials offered to them with an ecocritical perspective by relating them to the problems at a local or global scale is of great importance in terms of supporting sustainable development.

Thus, the purpose of this study is to develop ecocriticism skills of primary school students in the third grade. The concept of "ecocriticism skill" hasn't been used in the literature yet. Ecocriticism skill in the study denotes analysis, interpretation, and inference of linguistic and audiovisual stimuli from an ecocritical perspective. Responsibilities of individuals towards the natural world define in two views: Anthropocentrism and non-anthropocentrism. According to anthropocentric view, only human beings have moral values and dominate the natural world. Non-anthropocentric view loads moral meanings to such natural objects as animals, plants and landscapes (Jakobsen, 2017). The individuals who have gained ecocriticism skills are expected to create an awareness concerning possession of a distinctive value and to direct towards a non-anthropocentric understanding from an anthropocentricism understanding.

Method

Research Model

Action research design has been used in this study which aims to develop ecocriticism skills of primary school students. Action research aims to create practical solutions to problems in order to create change in learning environments (Esterberg, 2002; Melrose, 2001). It also provides a useful research approach in experimenting with new ideas. (Kemmis & McTaggart, 1988; Casey, 2007). The participative role of the researcher in the action research and her/his closeness to data ensure that the processes of participation-reflection and development in the research actualize effectively (Stringer, 2008; Yıldırım & Şimşek, 2011). The researcher teacher performed the implementations by participating in activities and discussions in person. Action research design was preferred due to the nature of a research problem and the role of researchers.

Participants of the Research

It is important to introduce ecocritical skills to children at early ages. The most proper grade level to relate ecocriticism with curriculum is third grade science course since the Turkish science curriculum starts in the 3rd grade. The research was performed with the 3rd-grade students of a primary school in Rize province located in the north-east of Turkey. A total of 15 students composed of 8 females and 7 males participated in the study. As per the nature of action research, it isn't always possible to obtain generalizable results since the sample selection from a wide population with a random sample method isn't obligatory (Fraenkel & Wallen, 2000). In this regard, the study was performed with the individuals who were directly related to the problem, i.e. with a designed group.

Data Sources and Analysis

Data of the study were obtained with rhetorical discussion, analytical discussion, mind maps and drawings. In rhetorical discussion considered to be a part of the culture in literature, an event is ensured to be seen from different perspectives multi-dimensionally and the assertion is attempted to be proven with the evidence as a way of defense and persuasion (Demirel, 2015). Rhetorical discussions also named as didactic discussions are defined as a series of expressions connected to each other in order to create a certain position; they ensure seeing an event from different angles multi-dimensionally (Boulter and Gilbert, 1995; Jimenez, Rodriguez and Duschl, 2000; Kuhn, 1992; cited by Aldağ, 2005).

Deduction and induction methods were used in the analytical discussion process in which the processes of comparison, material use and utilizing evidence by structuring logic principles were performed. First, rhetorical ideas of students about the topic of discussion were taken in the study. Rhetorical discussions have started with introduction of ecocritical tools to students. Orientation was provided by drawing attention to ecological elements under the guidance of a teacher. Afterwards, scientific explanations were attempted to be obtained through induction and analytical discussions were held. The researcher teacher recorded the comments of students with reminder notes in the discussion process. At this stage, video recording was performed and a discussion of data were obtained. Following the discussions, the students were given the tasks of mind maps or drawings. Without putting any limitations to students in both tasks, how the students were affected from the process and how they approached the problem were tried to be determined by complying with the topic and content of the discussion.

Concerning environment and sustainability, use of children's drawings and other visual tools (for instance mind maps) are gradually becoming popular as a systematic tool in order to evaluate the perceptions and attitudes of children towards the environment (Barraza, 1999; Walshe, 2008). Children's drawings can be used in determining their attitudes towards certain environmental problems as emotional indicators. In previous studies, the perceptions and expectations of children about sustainability (Barraza, 1999), change in their perceptions towards nuclear power stations (Brown, Henderson & Armstrong, 1987) and their mental models about the world (Çelik & Tekbıyık, 2016) were presented by using their drawings. Similarly, King (1995) tried to explore the children's concerns about the environmental crises through drawings. In this regard, it is observed that children's drawings are highly effective tools in reflecting their opinions, particularly about environmental topics. In this study, the students were expected to reflect their ecocriticism skills through drawings and mind maps following the above-mentioned discussion process.

Mind maps are the tools with which ideas and concepts about a subject are presented visually (Eppler, 2006). Two halves of the human brain perform different tasks. The left side of the brain is mostly responsible for such processes as logic, words, arithmetic, and ordering. The right side of the brain carries out the tasks related to multidimensionality, imagination, emotion, color, rhythm, and shapes. The combination of logic and imagination is represented in this technique which stipulates the use of both sides of the brain (Brinkman, 2003). Taking into account this attribute of mind maps and development characteristics of students, mind maps were utilized in the study with the purpose of reflecting their ecocriticism skills. Since the students have previous experience concerning the creation of a mind map, they don't have the difficulty.

Data obtained from the discussions and drawings in the study were analyzed with content analysis. Mind maps being the other data source of the study were descriptively analyzed. Discussions were recorded with the video camera. While the camera records are being written, the researcher who conducts the discussions is coded as RT and the students are coded as S1, S2, S3, etc. To ensure the reliability of the content analysis of the discussions, two researchers worked on the same data separately. The written data were analyzed in three stages. These stages are defining categories, identifying anchor samples and determining coding rules (Mayring, 2015). The analysis was conducted by two researchers. The reliability of the analysis was calculated by using the formula of Miles and Huberman (1994) by determining the researchers' same and different opinions. Consistency between independent encoders was found to be high (92%) and an agreement was reached on non-compliant encodings. In the content analysis of the drawings, two researchers determined the themes in which the drawings would be categorized. After the implementation of various materials, it was seen that students made drawings on different themes. In this respect, researchers came to an agreement and defined the themes of the drawings and named them.

It was tried to determine how often the students associated the central concept with other concepts in the mind maps that they produced by making one-stage relationships around the central concept. The concepts in their mind maps were represented descriptively and frequencies were formed (Weber, 1990). In this process, the themes and categories to which the associative concepts belong were determined by two researchers. In this way, the most frequently repeated concepts and the themes to which these concepts belong were presented.

Implementation Process

The study was conducted with seven consecutively performed implementations and visual, linguistic and audiovisual materials were used in the implementation process. The topics of climate change, sustainable production, and consumption, protection and management of natural resources and animal rights were investigated through these materials within the context of ecocriticism. The tools of discussions, drawings and mind maps through which students could express themselves in different ways were used in the process both for the development of ecocriticism skills and data collection. The materials used during the implementation process, sustainability dimensions aimed by these materials and ecocritical tools are presented in table 1.

Table 1. The materials used during the implementation process

Material	***Sustainability Dimension***	**Ecocritical Tool**
1. Image: Keklik Ailesi (Partridge Family) (Anonymous)	Climate change	Discussion, Mind map
2. Comic: Global Warming (Anonymous)	Climate change	Discussion, Drawing
3. Image: Agricultural fields must be protected… (TUCA, 2014)	Sustainable production and consumption	Discussion
4. Tale: Sürüsü Azalan Çoban (Shepherd with Reduced Herd) (Gökduman, 2015)	Protection and management of natural resources	Discussion, Mind map
5. Song: Baltalar Elimizde (We Have Axes in our Hands)(Anonymous)	Protection and management of natural resources	Discussion, Mind map, Drawing
6. Tale: Ham Mısır ile Tam Mısır (Raw Corn and Whole Corn) (Yazgan, 2011)	Sustainable production and consumption	Discussion, Drawing
7. Animation: Bambi (Hand, 1942)	Protection and management of natural resources	Discussion, Mind map, Drawing

First, the implementations as a *preparation* of ecocriticism were conducted in the study. For this purpose, the students were attempted to be aware of the problems in nature and to offer their ideas concerning these problems through images and comics. The discussion was extended with the new questions in line with the opinions of students. In discussions, guiding questions were used to help students address the problems in nature from different aspects. The problems experienced in nature and close environment were analyzed within the context of living-nonliving beings. In order to raise awareness regarding the socio-economic reasons and outcomes of the problems, the students questioned whether it was necessary for humans – being the source of the problem – to undertake responsibility in solving this problem in the second part of the process. The purpose here is to ensure that children can be a critical reader/audience regarding how the nature is reflected in cultural works that appeal to them and they are aware of the fact that each of all elements in the nature carries a subject value. In the second part of this process, an analysis on how the nature and problems in nature were addressed in works was performed with analytical discussions. Within the scope of this condition, the proposition that each element of the unity of life and liveliness in nature possesses the value of subject was approached with rhetoric discussions.

Table 2. Sample ecocriticism materials and relevant discussion questions

	Poem: Baltalar Elimizde (We Have Axes in our Hands) (Anonymous)	Tale: Sürüsü Azalan Çoban (Shepherd with Reduced Herd) (Gökduman, 2015)
Ecocriticism Material	We have axes in our hands, a long rope around our waists We go to the forest hey into the forest. (A1)We choose an old log and stand face to face, We saw trees off, hey saw off. (A2)Stand by the tree, hit the axe from the right side. Hit strongly also from the left When woods are burnt in winter, blames blaze, (A2)We sing songs and play, hey play.	...Because people in the village of shepherd take the trees for granted. (B1) Everyone grabbing an axe enters into the forest and cuts all green and dead trees. The shepherd feels so sad about it. … (B1) The old plane tree says: "Dear shepherd, what your village has suffered is caused by (B2) ignorance and selfishness. (B1) "If everyone hadn't entered into the forest and cut the trees randomly, you wouldn't have been in poverty today.
Discussion Questions	Analyze the sentences numbered (A1) and (B1). Please state if optional woodcutting can be performed. Read the sentence (A2). Do you think people are happy when they cut the trees? Compare the old log in (A1) part and old plane tree in (B1) part. Should every old tree be cut down? Who is the ignorant and selfish as stated in (B2) part, what are the consequences? Is cutting trees by playing and singing songs selfish? Why? What does it require to be eco-friendly? What do you think about the poem by considering the parts in A1 and A2? What do you think when you see other works similar to the attitude in poem, how do these works affect the society?	

Moreover, comparative analyses were conducted on different texts addressing the same topic in discussions and to what position the difference of language and style carried the text was discussed. As an example of this implementation, the song and tale describing wood chopping in the forest are indicated in Table 2. Similarly, the discussion was performed with the questions determined with the purpose of comparatively interpreting the style used and the message sent. Also, mind maps and drawings were prepared in order to allow students to reflect their opinions.

As is known, the language used in identity acquisition of individual plays a significant role. The cognitive structure of individual is created through the relations within the language as stated in the constructivist view (Best & Kellner, 2011). In the sample discussion presented in Table 2, the implementation method of ecocritical inquiry is observed. The situations described in the text are examined separately and the efforts are made to ensure realizing which messages can be created by different styles.

FINDINGS

Findings Obtained from the Discussions

In rhetorical and analytical discussions, students performed a critical analysis in terms of determining the reasons and significance of a problem experienced in nature, making an inference concerning the domain of problems in nature and life and observing the relational dimensions of unity of life in nature. Below is a cross-section of the discussion performed to explain the image which tells the life of the partridge family who had to migrate due to the negative impact of climate change (*RT: Researcher Teacher; S3: Student 3*):

RT: What would happen if partridges didn't exist?
S3: Their babies can't live. We can't eat egg. It is a sin to kill partridge, The God forbids it.
RT: Have you heard about ticks?
S3: Yes, they adhere to your skin and make you sick.
RT: Poultries reduce ticks, so what will happen if partridges become extinct?
S3: Ticks infest everywhere. Ticks adhere to people and people die.
RT: So, who has the highest responsibility?
S3: People.
RT: It seems everything is connected; how can this be explained?
S3: When the number of partridges reduces, ticks increase and people's life endangers.
RT: How does the absence of partridges in the relation of Partridge-Tick-Human affect nature?
S3: Nature's balance is impaired.

Looking at the flow, the analytical discussion that develops as answers given by the students to the questions asked by the teacher is observed to transform into a rhetoric structure towards the understanding of "unity of life" and "integrity in nature". It is understood that the discussion process allows students to see the different dimensions of the problem. When all discussions are analyzed together, the discussions are observed to be conducted around two main themes as "Anthropocentricism" and "Non-anthropocentricism". The schematic indication of the findings obtained with the analysis of these discussions is presented in Figure 1 and Figure 2.

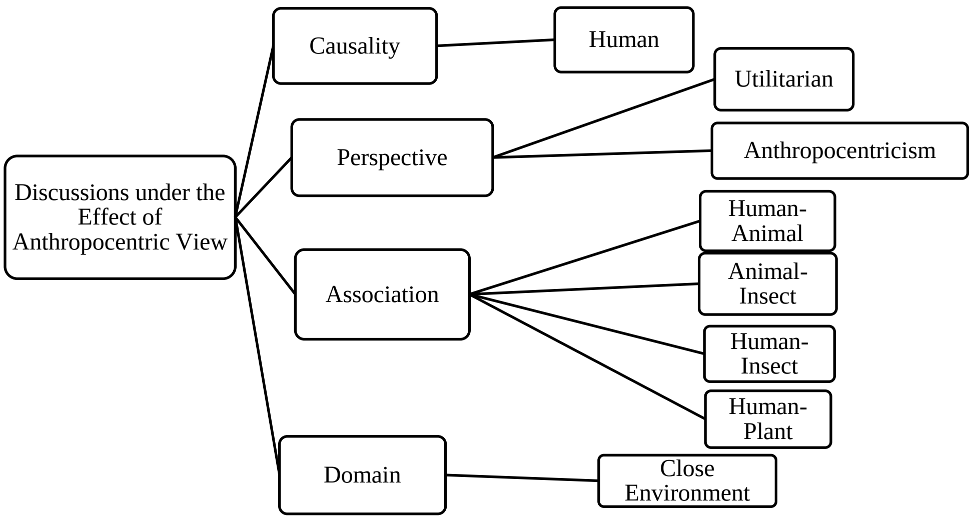


Figure 1. Content analysis of the discussions under the effect of anthropocentric view

Figure 1 shows the findings obtained following the discussion of images and comic contents which have the characteristics of preparation study for development of ecocriticism skills of students. It has been determined after the analysis of these discussions that students point out to humans as the main reason of the problems in nature. It is also stated in the discussions that students criticize with a more utilitarian and anthropocentricism perspective in addition to including association with living elements in nature. Regarding the statements of students during the discussion of visual content while addressing the effect of building houses on cultivated areas [*'If tea doesn't grow; we will lose the money coming from tea; factory workers can't get paid and unemployment occurs'. 'If plants don't exist, oxygen and clean air decreases, people can't find food if natural balance is impaired'.*], it is observed that humans are emphasized as the most affected being from the problems in nature and future concern is explained with the expressions favoring the benefits of human.

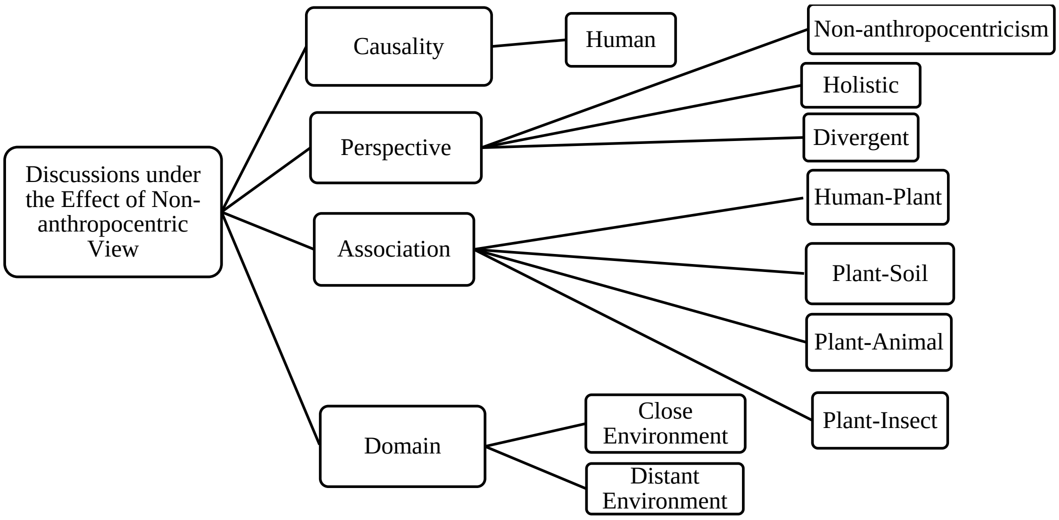


Figure 2. Content analysis of the discussions under the effect of non-anthropocentric view

Figure 2 shows the content analysis of the findings obtained from the implementations performed following preparation study for development of ecocriticism skills of students. The students are observed to interpret a problem in nature with a holistic perspective through the discussion of the contents of stories, songs, tales and animations. Analyzing the statements of students *[If you cut the forest, caterpillar can't be fed. Owls and moles can't build a nest. Humans don't have the energy. If forests are cut down, there is no oxygen and living things could disappear],* it has been determined that a problem in nature is analyzed by students within the context of human-plant-animal relationship. It is understood that students criticize the problems by looking out the unity of life and integrity in nature. It has also been observed that students consider other living beings apart from humans as subjects and criticize the problems by showing an emotional sensitivity to non-human beings with such expressions as *[Trees are also alive. When the trees are cut, there is no such thing as natural life, the natural balance is lost. The forest is the home for trees. There is brutality and insensitivity here...].* It has also been ascertained that the students analyze the problems by considering the distant environment [*Without trees, snow melts due to global warming. Glaciers are melting, polar bears cannot find food]* and interpret them with a divergent perspective.

Findings Obtained from Mind Maps

Following the discussion of images, animation, songs, and tale, the focal concepts directed to these activities were determined and mind maps were created around these concepts. 'Air and water pollution' was selected as the focal concept after the ecocritical discussion of images, and relevant concepts and situations were ensured to be determined. Similarly, the concepts of 'forest' after the song, 'natural environment' after the animation activity and 'nature' for the tale activity were established as key concepts; the effect of ecocritical discussions was attempted to be revealed within the relational context.

Figure 3 features the examples classified according to the characteristics of mind maps drawn by students. Looking at the mind maps, the students are observed to have substantial ecological concepts. In addition, specific drawings are included in which a holistic cross-section taken from nature (e.g. forest) is represented, which adopts a non-anthropocentrism approach that considers the living and non-living elements together in nature. Other mind maps analyzing the reasons of environmental problem (e.g. air pollution) from different dimensions and trying to represent the natural cycles were observed.

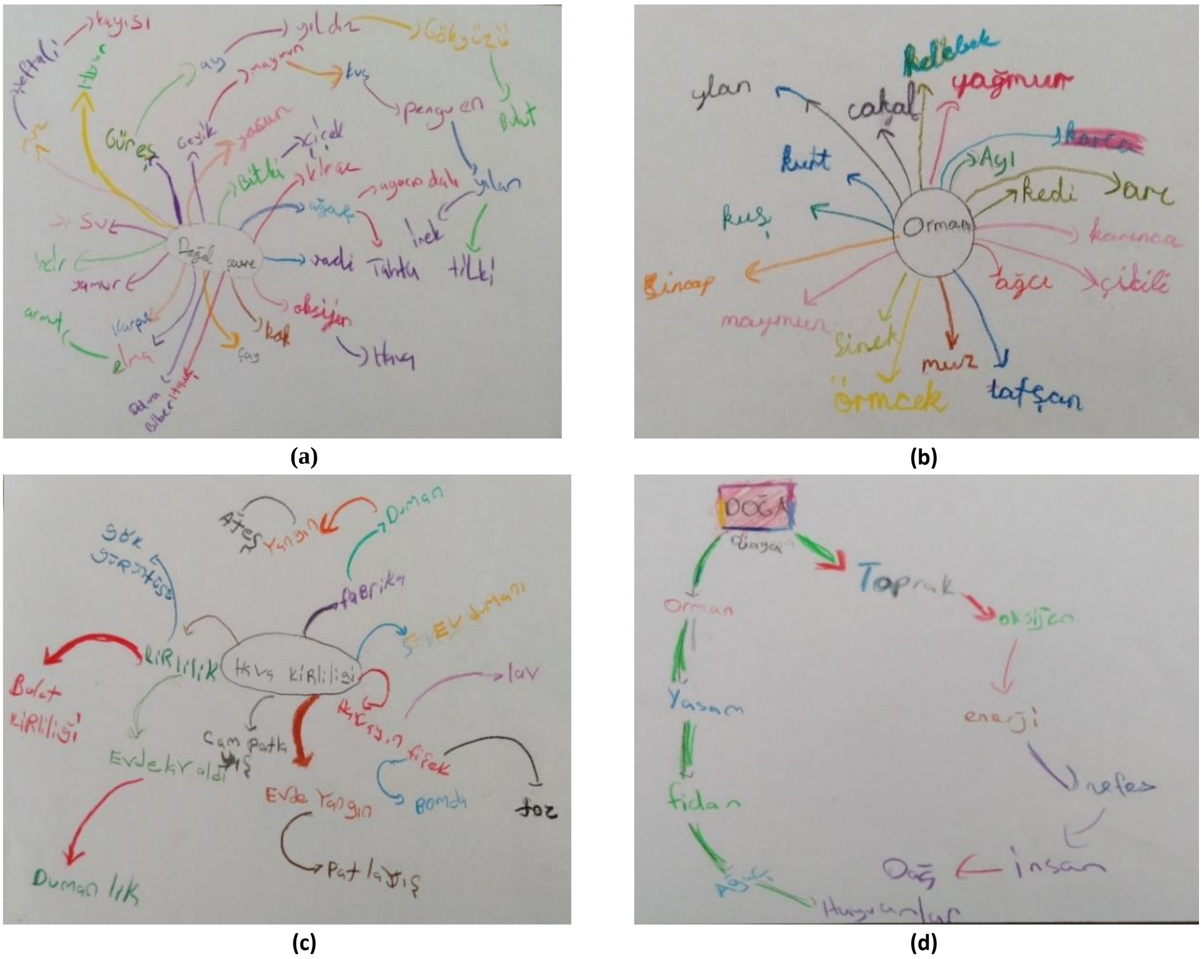


Figure 3. Classification of mind maps by their characteristics [(a) holistic display adopting the non-anthropocentrism approach, (b) specific display adopting the non-anthropocentrism approach, (c) causal display adopting the non-anthropocentrism approach, (d) spiral display adopting the non-anthropocentrism approach]

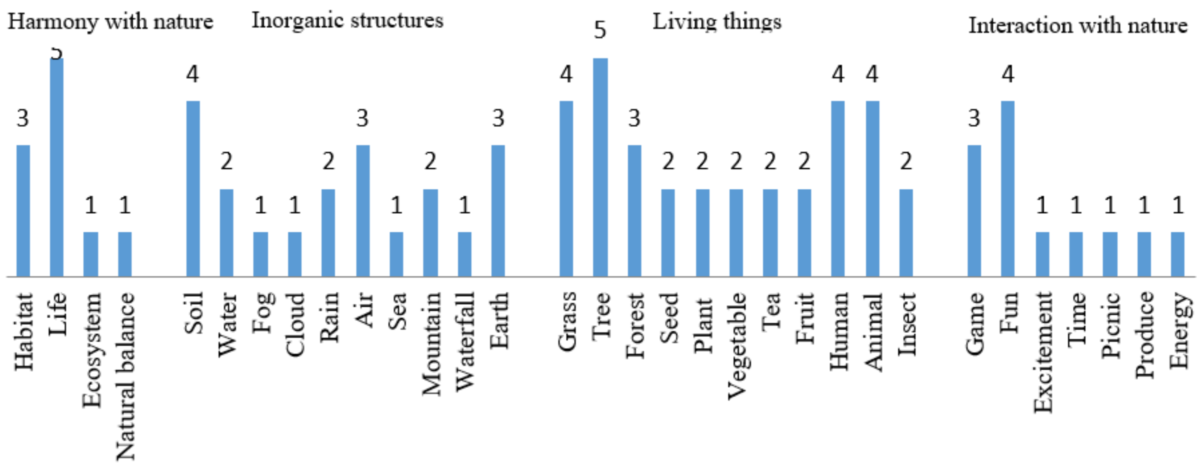


Figure 4. Concepts associated with the concept of nature

Looking at Figure 4, it is seen that students associate the concept of nature with such inorganic elements as soil, water, mountain, etc. and such living beings as plant, tree, forest, human, animal and insect. It is also another finding that students associate nature with the concepts of living space, life, ecosystem, and natural balance and the concepts of game, fun, excitement, picnic, time and production are used in this association.

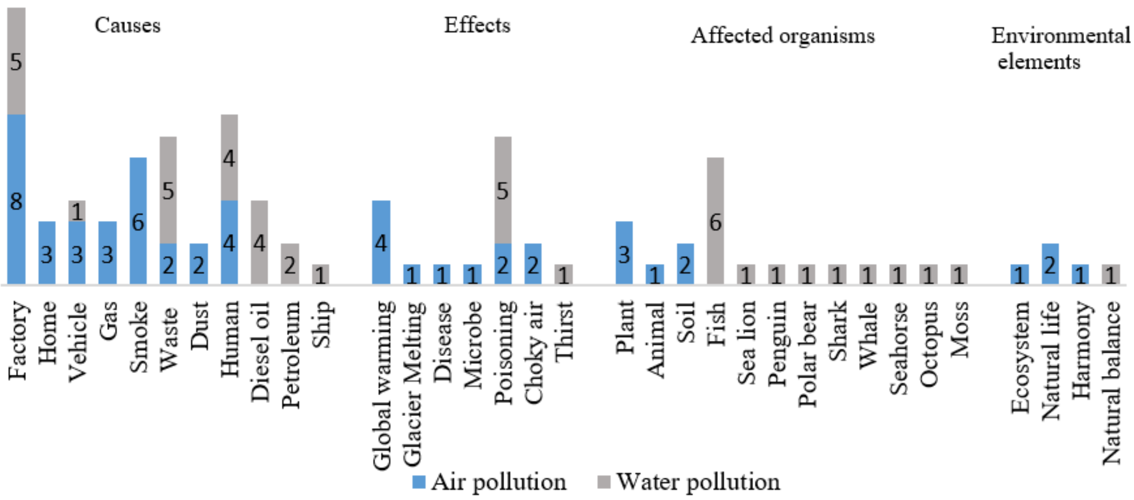


Figure 5. Opinions of students about air and water pollution in their mind maps

Figure 5 contains the associated concepts of the students directed to the environmental problems caused by air and water pollution. It is observed in the figure that the students associate this concept with mostly factory and human concepts in terms of the factors that cause environmental pollution and the elements of vehicle, trash, diesel oil, and petroleum are used in this association. Concerning the outcomes caused by environmental pollution, students associated this concept with global warming, poisoning, disease, glacier melting, and thirst. It has been ascertained that the concepts of plant, animal, and soil are affected from air pollution within the scope of being affected from environmental pollution while the concepts of fish, penguin, whale, moss, octopus and polar bear are the living beings in the association affected from water pollution. Similarly, the concepts of ecosystem, natural life, harmony, and natural balance exist in this association.

Findings Obtained from Drawings

Following the ecocritical discussion of images, animation, tale, and songs, the students were given the task of drawing. The drawings were made to reveal what kind of impressions the discussed works and materials would arouse in the students. Drawing I was performed after the discussion and analysis of the comic and Drawing II was performed following the display and discussion of the animation movie Bambi. Drawing III was made after reading and discussing the tale *Ham Mısır ile Tam Mısır (Raw Corn and Whole Corn)* and Drawing IV was made after the activities of listening-discussing the song *Baltalar Elimizde (We Have Axes in our Hands)* and reading-discussing the tale *Sürüsü Azalan Çoban (Shepherd with Reduced Herd)*. Regarding the findings obtained from the drawings, it is observed that the relation of affecting-affected directed to a situation in nature is addressed in drawings and what is told in these drawings is that all living and non-living elements are affected from a problem commonly.

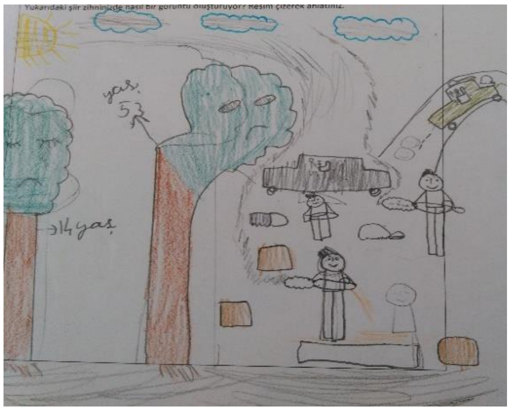
Figure 6 contains the examples from drawing activity performed following the discussions. Looking at drawing (I), it is understood that the student points out to factory as the reason for global warming, the plant life is endangered as a result of global warming, flowers fade, air pollution increases due to these outcomes and the environment reaches to a grey and black appearance as this process continues. In the drawing (II) made by another student, the harmony in nature is described. When the drawing is examined, the harmonious association in wildlife expressed independently from humans stands out. This drawing was made after the discussion of animation movie Bambi and the damage given by irresponsible individuals to wildlife was addressed in discussion. It has been determined in the drawing that no negative condition is observed in natural life where human doesn't exist and a system is expressed in this harmonious association (crows are eating apples, the deer walks around the green grass, insects flying in a sunny weather).

The drawing (III) was made after the discussion of the content of tale describing the journey of a sweetcorn. The discussion was conducted over what kind of results could occur if unnatural methods were used by intervening in the development of a normally developing sweetcorn. Analyzing the drawing of the student, the production by natural methods is observed to be compared with the production by unnatural methods. It is understood from the drawing that the production performed with unnatural methods is described in an exaggerated way, and this method of production is ironically criticized. A realistic expression is adopted in describing the way of production with natural methods; there exists an expression that this production method is acceptable with the drawings of vegetables and fruits.

(I)
Ecocriticism of the comic reflecting the effect of global warming: The negative condition caused by air pollution in nature and the factors causing this are explained.

(II)
Ecocriticism of the animation movie telling the life of a deer: The harmony of living and non-living elements in nature is explained.

(III)
Ecocriticism of a tale telling the journey of a sweetcorn: The production by natural methods is compared with the production by unnatural methods.



(IV)
Ecocriticism of the song telling the woodchopping in forest: The fact that cutting old trees will not always be true, the pollution after woodchopping and the factors causing this situation are explained here.

Figure 6. Holistic expressions in drawings

The drawing activity (IV) has an enthusiastic description in terms of rhythm and it was performed after the discussion of the content of song *Baltalar Elimizde (We Have Axes in our Hands)* and the tale *Sürüsü Azalan Çoban (Shepherd with Reduced Herd)* which introduce woodchopping like a part of daily life with a game-like expression. It is observed from the drawings that tree is defined as a subject, an empathetic bond is established with the tree by ascribing such humanistic attributes as feeling sorry and crying, humans cause the damage in nature and this damage will result in various problems especially air pollution.

Discussion and Conclusion

In this study we performed to develop ecocriticism skills of third-grade students in primary school, the students have been ensured to analyze cultural works from a perspective being sensitive for nature and environmental problems. Following the implementations composed of discussions, mind maps and drawings, it has been determined that the students can analyze a problem experienced in nature with a holistic interpretation and they can criticize the effects of the problem on the unity of life of living and non-living beings and the outcomes. The fact that children analyze the problems of today's world through the cultural works at early ages and examine the content of these works by questioning how the bond created with nature should be has caused them to observe the situations in life with a critical, analytical and holistic approach. How the relationship between human and nature is described in the work is the main problem on which ecocriticism has focused and the ecocritic is on guard against the nature and environmental problem created in the work (Garrard, 2004). Among the implementations, the students interpreted not only the ready contents, but also the literature produced in free writing activities from the ecocritical perspective. During the free writing activity, a student described in her/his story that a jackal attacking chickens in a farm was killed by the farmer, which was criticized by the student’s friends listening to this story and the students told their friend that the story should have ended with a less violent fiction with no guns and killing. It can be stated in this case that the implementations develop the ecocritical inquiry skills of students.

In the literature, there is no agreed upon method for the implementations of ecocriticism (Arıkan, 2011). Considering the based on ecocritical understanding of environmentally-friendly individuals, the discussion method that stirs the connection of asking- inquiring-interpreting was used in the study. The discussion method is observed to be effective in equipping with critical thinking skill (Seferoglu & Akbıyık, 2006). The fact that students convey their ideas easily in class and can see a problem from different perspectives has enabled them to analyze the relation of human-physical environment in cultural works with an interdisciplinary approach and to interpret the nature image in the work with a holistic approach.

Another striking dimension of the study is that students attribute subject value to the life of living beings in nature and wildlife. The fact that students reflect the emotional exposure of plants and animals against possible destruction of nature in their drawings and discussions and how humans jeopardize them constitutes a basis in creating an ecological self. The relationship and diversity in nature, ecological cycle, the functioning of the food chain, the integrity of different species and perception of holism in natural life are important in the development of ecological self (Çukur & Özgüner, 2008). The integrity in nature in ecocriticism and the emphasis on human’s being aware of the position within the whole make a direct contribution to the development of ecological self. It could be said that the findings of the study comprehensively support this argument.

It has been understood from the discussions in the introduction part of the research that certain students show a tendency to the violent computer games among the situations observed by the researcher. One of these games is hunting games in which all wild animals in the forest are targeted, points are collected when animals are killed and violence is displayed with an entertaining view. In the later stages of the discussions, it was identified that students criticized computer games in terms of not only wildlife but also all contents that include violence. It was ascertained that the students who said to have deleted this game from their computers at home adopted a sensitive attitude towards living beings such as plants, insect, reptiles etc. in the school yard. The students were observed to make a warning or to inform school administration and teachers when a living being such as a sapling or lizard was damaged in the school yard.

Another point that needs to be emphasized in mind maps in the study is that the concept of nature has been associated with the notions of game, fun, excitement, time, picnic, energy and production. The fact that students consider the nature as a lively, active and joyful ambience to spend time can be interpreted as an opportunity for them to blend with nature. The ecocritics state in their analyzed works that alienation of nature is due to the distances put between human and nature (Oppermann, 2012). It is thought that implementation of ecocriticism may create awareness in the dimensions of nature and the meaning attributed to nature in children and a nature integrated sense of self can be developed through these implementations.

In the study which was performed to develop ecocriticism skills of the third-grade students in primary school, the students were ensured to analyze the representation method of nature in visual, audio and written works within the ecocritical scope. It has been determined through the implementations that students have created an awareness concerning the topics of considering non-human beings in nature as subjects, being aware of the integrated structure of nature and the necessity for people to undertake responsibility in protecting this structure. It has been established that the implementations are effective not only in uttering the protective precautions after determining the problems, but also in behavioral dimension, the students exhibit an eco-friendly approach in their own lives and environments.

Recommendations

In the light of these results obtained from the study, following suggestions can be made for researchers and educators:

- Children's literature works, animation movies, computer games etc. and the content of audiovisual and literary materials for children can be examined within the ecocritical context.
- A perspective can be created towards aligning the daily life practices with the nature by expanding the domain of the implementations of creative writing based on ecocriticism, environment education and critical reading.
- The students can be enabled to see the socio-cultural environment from a critical perspective through the ecocritical implementations and to be sensitive towards nature and ecological life.
- Discussion, mind maps and drawings could be used in the determination of the ecocritical views or similar critical ideas of primary school students. These tools have been shown to be effective for reflecting students' ideas.

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Examining Science Teachers' Decisions about Nuclear Power Plants from the Perspective of Normative Decision Theory

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Abstract

This study aimed to determine science teachers' decisions about the socio-scientific issue of nuclear-power plant and how these decisions are given within the framework of the decision making process. The design of this research is based on a case study. 22 teachers who worked in the middle schools in the city center of the province of Sinop were recruited for the study. The data were collected through the semi-structured interviews. The data obtained through these interviews were analyzed qualitatively. For the analysis of the data the opinions of the teachers were discussed according to the steps of the decision-making process based on normative decision theory. The knowledge levels of science teachers about nuclear power plants were mostly found to be partially sufficient. It has been determined that science teachers evaluate the socio-scientific issues of nuclear power plants mostly with the dimensions of economy and environment.

Introduction

With the advancement of science and technology, human activities have led to social, ethical and moral conflicts (Lee & Witz, 2009). These developments may affect the multi-dimensional thinking and decisions of individuals, and this may undoubtedly affect the future of societies in many aspects such as economic, political and environmental. Many issues such as cloning, global warming, gene therapy, stem cells, organ donation, alternative fuels, GMOs (Genetically Modified Organisms), chicken meat, surrogacy, abortion, hydroelectric power plants, nuclear power plants, etc. cause people to be on the horns of a dilemma because of economic, political or environmental reasons and are considered as controversial subjects (Chang Rundgren & Rundgren, 2010; Presley et al., 2013; Sadler & Zeidler, 2004; Sadler & Zeidler, 2005; Sadler & Donnelly, 2006; Sadler, 2004; Topcu, Sadler & Yılmaz-Tuzun 2010; Wu & Tsai, 2012). Constituting a dilemma in individuals, these issues are defined as socio-scientific issues (SSIs) since they are at the intersection of both social and scientific dimensions (Sadler, 2004). SSIs are complex, open-ended and controversial subjects with no simple and single solution (King & Kitchener 2004; Kolstø 2001). At the same time, the SSI provides a forum for discussion about the current science and technological developments through their social, scientific, political, economic and ethical dimensions (Chang Rundgren & Rundgren, 2010; Eggert et al., 2013; Sadler, Barab & Scott, 2007; Zeidler et al., 2005). SSIs don't have any complete and right solution. SSIs are always open to different solutions since it may involve a positive or negative approach (Kolstø, 2001; Sadler, 2009; Zohar & Nemet, 2002). SSIs also include the aspects of having local, regional and global dimensions from social and political perspectives and offering topics from real life (Ratchliffe & Grace 2003).

Nuclear Power Plants as a Socio-Scientific Issue

Nuclear energy is defined as the energy arising from the disintegration of the atomic nucleus. The nuclear power plant is a plant that generates electricity using radioactive materials as fuel through one or more nuclear reactors. The concept of a nuclear power plant is an issue that is on the front burner because it is planned to be established in cities such as Sinop, Mersin in Turkey and that the process of the agreement is broadcasted on media. The concept of nuclear power/nuclear power plant is known to our citizens mostly by the Chernobyl accident, which occurred in 1986 and caused severe damage. After this accident, the perception of the nuclear plant as being a risk against health and environment is developed in the society. Similarly, the nuclear accident that occurred in Fukushima in 2011 made individuals more sensitive to the health and environment aspects of the problems arising from nuclear energy (Ramana, 2011). There are ongoing works related to Akkuyu Nuclear Power Plant (in Turkey) the foundation of which was laid in 2018 following the agreement that was signed between Russia and Turkey in 2010 and which forms the basis of an important discussion in our country in the recent years and to Sinop Nuclear Power Plant (in Turkey) which was signed between Japan-France partnership in 2013.

The issue of nuclear power plant draws the attention of the public in terms of social and sustainable development and constitutes an important context in terms of its effects (Jho, Yoon & Kim, 2014). It is important that individuals become aware of these current issues related to science, technology and society and make informed decisions (Bossér et al., 2015; Chang & Chiu, 2008; Eggert & Bögeholz, 2010). Kolstø et al. (2006) who point out that it is difficult to make decisions about SSIs, emphasize the need to consider many dimensions such as political, ethical, scientific during the decision process. It is important to make judgments and analytical decisions taking into account many of the dimensions of these multi-dimensional issues. There are researchers that take into consideration the related attitude and point of views of the pre-service science teachers (e.g. Ates & Saracoğlu, 2013; Cansız & Cansız, 2015; Ercan, Ural & Tekbıyık, 2015; Eş, Işık Mercan & Ayas, 2016; Evren Yapıcıoğlu & Aycan, 2018; Kapici & Ilhan, 2016; Özdemir & Çobanoğlu, 2008; Özdemir, 2014; Yener, Aksüt & Somuncu Demir, 2017), teachers (Kenar, 2013; Lee & Yang, 2013) and students (Jho et al., 2014; Wu & Tsai, 2007; Yang & Anderson, 2003) towards nuclear power plants. A limited number of research was conducted with teachers (Kenar, 2013; Lee & Yang, 2013). The researchers conducted with pre-service teachers and teachers in relation to the study group of this research are as follows.

In the research that they have realized with pre-service science teachers, Ates & Saracoğlu (2013) have found out that most of the pre-service teachers have positive considerations in relation to nuclear energy in terms of generating electricity and energy, and providing prestige. It has been found out that the pre-service teachers who have negative considerations about nuclear energy have given apprehensive answers because of problems such as dangerous weapon production, possible serious accidents, cancer and radioactive leak. Cansız & Cansız (2015) have made a research on the views of pre-service science teachers studying in Ankara in relation to the Akkuyu nuclear plant and reported that pre-service teachers have a negative opinion in relation with the establishment of a nuclear power plant in Turkey. In their study that has been conducted with pre-service science and social studies teachers, Kapici & Ilhan (2016), have found out that pre-service teachers are not knowledgeable about the working principle of the nuclear power plant; but that pre-service social studies teachers have a positive attitude towards nuclear energy whereas pre-service science teachers have a more negative attitude. In their study; Eş, Işık Mercan & Ayas (2016) have investigated the knowledge and opinions of pre-service teachers who have been continuing their education in different departments in Sinop. In the study, it is concluded that the pre-service teachers have limited knowledge about nuclear energy, that their information resource is the media, that the pre-service teachers do not want to live in a province where there is nuclear energy and that the number of positive and the number of negative opinions on the establishment of nuclear power plant in Turkey are close to each other. Evren Yapıcıoğlu & Aycan (2018) have investigated the effect of the socio-scientific issue-based instructional activities related to the Nuclear Energy Plants (NEP) that have been attempted to be made widespread in Turkey on the pre-service science teachers' decisions, positions and types of informal reasoning they use while making their decisions. In this study it was found that while making their decisions, before the application, they were mostly engaged in the ecology-based informal reasoning; after the application, they mostly utilized the social type of informal reasoning. Lee & Yang (2013) have examined the attitudes of high school technology teachers towards nuclear energy. It has been concluded that the technology teachers in Taiwan are interested in the news about the disaster that occurred in Fukushima, Japan and that they have less support for the growing nuclear plant establishment in Taiwan and that they prefer the use of renewable energy sources such as wind and sun instead.

The above-mentioned researchers provide the approaches of teachers and pre-service teachers who face or don't face the nuclear energy in real life, about the nuclear energy issue, taking into consideration these approaches in relation to various variables. An important issue with the SSIs is how these decisions are made when developing positive or negative approaches. In fact, various researchers determined that participants' knowledge of the nuclear power plant is incomplete, but they still have positive or negative opinions on the matter (Eş et al., 2016; Özdemir & Çobanoğlu, 2008). In this context, it is crucial to investigate how individuals decide in relation to the SSIs.

Decision Making and Socio-Scientific Issues

The fact that it includes different solutions and that it can have a different understanding when it is viewed from different dimensions such as ethics, environment and economy makes it inevitable for the SSIs to be controversial (Levinson, 2008; Zeidler, 2014). For this reason, methods such as classroom discussion and debates are often preferred when planning teaching processes in which the SSIs are in focus (Acar, Turkmen &

Roychoudhury, 2010; Levinson, 2006; Zeidler et al., 2005). Deciding on these issues that do not have a single correct solution requires taking into account specific criteria and constraints and considering their relative importance. In this manner, the discussion of the SSIs in a class alone will be insufficient. Another aspect which is as vital as re-considering these issues is to make a decision. In other words, it is essential for students to reach a decision as a result of reconsideration, and it is necessary to include the practices that will employ the decision-making processes in the classes.

The execution of the decision-making process requires the existence of a problem statements' that includes more than one alternative (Svenson, 1996). In this case, the decision is made depending on the problem statement. In the literature, there are different approaches directed at explaining the decision-making process (Lipshitz, Klein, Orasanu & Salas, 2001; Ratcliffe, 1997). One of these approaches explains decision-making with two approaches: normative/analytical and summative. The holistic decision theory focuses on studying the intuitive and psychological processes while concentrating on how the decision is made. According to this theory, past experiences of people or other psychological factors influence decision-making. Normative decision theory focuses on how the decisions should be made rather than how they are made (Hansson, 2005; Jonassen, 2012; Ratcliffe, 1997).

According to this perspective in normative decision theory, the psychological processes that affect decision-making are ignored, and it is focused on how to make the best decision (Hong & Chang, 2004). Similarly, Hogarth (2005) explains the decision-making process through two different cognitive systems, being intuitive and analytical. While defining the intuitive decision-making system as unconscious and influenced by emotions, he points out that the analytical system requires consciousness and logical justification.

The individuals who are faced with the SSIs, which allow the operation of decision-making processes by their nature, will be influenced by their previous experiences, practices or mental models in their decision-making process (Fang, Hsu & Lin, 2018). However, when the teaching process of these subjects is structured to require analytical decision-making, individuals will tend to make analytical decisions even though the intuitive system will affect the decision-making mechanism. It is possible to understand the reasons behind the individuals' decisions about the SSIs through theories directed at the decision-making process (Wu & Tsai, 2007; 2011).

Normative decision-making theory allows dealing with decision-making as a process (Germeijs & De Boeck, 2003; Kortland, 1996). The decision-making process starts with the "*defining the problem*" (Lunenburg, 2010). At this step, it is necessary to examine the problem in depth and determine the features that the problem should have in order to obtain the best solution. Then, in the step of "*creating alternatives*", possible alternatives are investigated in order to solve the problem. The in-depth research of this step and the effect of each alternative on the outcome will affect the decision process. The next step is "*evaluation of the alternatives*". At this step, the solutions are expected to be evaluated within the framework of the criteria determined in the first step (Kortland, 1996; Ratcliffe, 1997). At this step, individuals evaluate each alternative within the framework of previously determined criteria and decide the most suitable alternative to solve the problem (Ratcliffe, 1997). Often, none of the alternatives may be sufficient to meet all the criteria (Baker et al., 2001). For this reason, different tools are referred to help decision-making at these steps (Hansson, 2005). Decision matrices, SWOT analysis, force field analysis (Jonassen, 2012), advantage-disadvantage assessment, analytical hierarchies (Baker et al., 2001) are some of these tools. For the decision-making process that may be considered to end with the "*most suitable alternative*", Lunenburg (2010) has included two more steps being "*the implementation of the decision*" and "*the evaluation of the effectiveness of the decision*". Depending on the results of their choice, the person has the opportunity to evaluate their success in the activities they perform during the process (Ratner & Herbst, 2004). In this way, even the decisions that are concluded negatively can be turned into an achievement for the decision making process that will continue during lifetime (Gauld, 2005; Raeva, Dijk & Zeelenberg, 2011).

In this research, how SSIs are decided is discussed in the context of normative decision-making theory, because it is important to determine whether individuals have a rational point of view towards the issue. Defining the problem phase of normative decision making can be considered as the stage in which the socio-scientific issue is understood. "Creating alternatives" and "evaluations of the alternatives" steps relate to what aspects can be addressed when evaluating the socio-scientific issue. "Determining of the most suitable alternative" step provides insight into how the decision is consistent with the dimensions discussed in the evaluation process. Such an assessment will enable individuals to determine which aspects of the issue they are taking in the decision-making process in relation to SSIs and to decide which of these dimensions is more important in making their decisions. This is important in order to conduct a more in-depth analysis beyond the determination of what is effective in the final decision. Therefore, in this research, an evaluation is made within the scope of normative decision making theory in order to examine the decisions about SSIs in depth.

The "decision making" skills that is among the 21st-century skills commonly defined by many international organizations and also that is among the life skills in the science curriculum in Turkey is an important skill defined in the framework of science literacy, which is the main objective of science education programs (MoNE, 2018). Various researchers point out that dealing the SSIs with suitable learning-teaching processes in science courses can provide an important context for students to improve their decision-making skills (e.g. Barrue & Albe, 2013; Jho, et al., 2014; Jime´nez-Aleixandre, 2002; Patronis, Potari & Spiliotopoulo, 1999; Sadler & Zeidler, 2005). In our country, however, there are findings about affecting the decision-making processes of students in the learning-teaching process in the studies on nuclear power plant (Kılınç, Stanisstreet & Boyes, 2013; Tekbiyik, 2015). Kilinc et al. (2013) aimed to determine the opinions of secondary school students about nuclear power plants planned to be constructed in Turkey. In the research, students have expressed that nuclear power plant in decision-making processes was beneficial with the contribution to the national economy and meeting the energy needs. However, students have indicated about that nuclear power plant is to be risky because of damage to the environment and global warming. In addition, socio-scientific based learning environments could include the trust in knowledge sources, the evaluation of current data regarding the risks of suggested technology, values, biases and cultural variables, gender roles in decision making processes. And this contributes to the evaluation of decision alternatives (such as benefit / risk) (Kılınç et al., 2013). Tekbiyik (2015) examined the opinions and decision-making processes of pre-service science teachers on nuclear power plant in the process of cooperative learning in his study. In this research, it is concluded that scientific literacy, knowledge acquired during the process of cooperative learning, awareness and content knowledge on the subject are effective in the decision-making processes related to the SSIs. Unlike these studies, in present study, it is tried to determine the case of reflect the teachers' decisions about the nuclear power plant analytical decision process.

Research Focus

The nuclear power plant project which is planned to be established in Sinop city of Turkey and on which the studies are accelerated is an SSI which some of the people in the province support, some of them do not support or remain undecided. As a matter of fact, the reaction of the public towards the nuclear power plant to be established in Sinop has sometimes appeared on media. In this case, it is considered necessary that science teachers working in this province have a decision about the subject and can explain this decision through a justification. As a matter of fact, the role of teachers in making students consider all aspects of the SSI and in raising them as science literate individuals by preparing learning environments that will develop students' decision-making skills cannot be denied. In this direction, it is the issue of concern of this research to reflect the analytical decision process of the teachers' decisions about the nuclear power plant which is a socio-scientific issue compatible with the context of the province where they live. The analytic (normative) decision-making theory focuses on how decisions should be made (Hansson, 2005; Jonassen, 2012; Ratcliffe, 1997).

Science teachers are expected to prepare a learning environment that will enable students to discover the multidimensional nature of SSI and improve their decision-making skills regarding these matters. Therefore, studying the ability of teachers themselves to approach the nuclear plant SSI from multiple perspectives and make decisions based on an analytical decision-making process rather than personal tendencies is important for the contribution it will make to the literature. It is also believed that the fact that the present research addresses with a phenomenological approach the decisions that science teachers who live in a province that involves a nuclear plant issue make about this issue will make a contribution to the literature in terms of revealing the analytic decision-making capabilities of the teachers who experience this phenomenon. The purpose of this research is to examine the decisions of the science teachers in relation to the socio-scientific issue of the nuclear power plant and how these decisions are made in the context of the steps of the decision-making process.

Method

The qualitative paradigm is taken as the basis for determining the study group, the data collection process and the analysis of the data in order to examine the decisions of science teachers in relation to the socio-scientific issue of nuclear power plant and how they have made these decisions in the context of the steps of the decision-making process. The design of research design is phenomenology. Because, the focus of this study is to investigate the decisions of science teachers living in Sinop, which is a city planned to build a nuclear power plant, about nuclear energy and the reasons for decisions. Phenomenologists focus on describing what all participants have in common as they experience a phenomenon (Creswell, 2007).

Participants

The SSIs are considered as concerning the society, controversial, up-to-date, subject to the decision-making of the individual, and are emphasized. The information, decisions of the science teachers' who take the responsibility of raising individuals who are able to make conscious decisions and who are engaged in occupying the agenda, about the nuclear energy that is planned to be established in the cities they live in and how they make this decision have a significance. This is taken into consideration in determining the study group, and 22 science teachers (ST) (14 female, 8 male) working in all the secondary schools in the central district of Sinop province are included in the study based on purposeful sampling technique (Creswell, 2012). The STs consisting the study group have an experience of 15 years or more (f=11), 6-10 years (f=6), 1-5 years (f=3) and 11-15 years (f=2) respectively. 11 of the teachers are graduated from science education, and 5 of them have a bachelor's degree in physics-chemistry-biology teaching. 6 teachers are graduated from the department of chemistry in the science faculty and received pedagogical formation. All of the STs have been working in Sinop province at least for 4 years.

Data Sources and Procedures

The data source of the study is the *Nuclear Power Plant Interview Form (NPPIF)* developed by the researchers. NPPIF is designed to determine the resources that teachers apply when making decisions about their definitions, decisions and reasons in relation to nuclear energy. In order to determine the comprehensibility and relevance of the form, it is presented to two science education experts who have researchers related to the SSI; and after receiving their positive opinion, the two science teachers have been interviewed. Together with the feedback received following the interview with the teachers, the form has taken its final form. The data of the study have been obtained by semi-structured interviews with the STs. In semi-structured interviews, questions were prepared before the interview, but changes can be made during the interview, questions can be asked confidently, and all questions can be used flexibly (Merriam, 2009). During the data collection process, each science teacher is interviewed for 20 minutes on a pre-determined date and time, and their voice is recorded with their permission.

Data Analysis

Normative decision-making theory allows dealing with decision-making as a process (Germeijs & De Boeck, 2003; Kortland, 1996). The decision-making process starts with the “identifying *the problem*" (Lunenburg, 2010). At this step, it is necessary to examine the problem in depth and determine the features that the problem should have in order to obtain the best solution. Then, in the step of "*generating alternatives*", possible alternatives are investigated in order to solve the problem. The in-depth research of this step and the effect of each alternative on the outcome will affect the decision process. The next step is "*evaluating alternatives*". At this step, the solutions are expected to be evaluated within the framework of the criteria determined in the first step (Kortland, 1996; Ratcliffe, 1997). At this step, individuals evaluate each alternative within the framework of previously determined criteria and decide the most suitable alternative to solve the problem (Ratcliffe, 1997). Often, none of the alternatives may be sufficient to meet all the criteria (Baker et al., 2001). For this reason, different tools are referred to help decision-making at these steps (Hansson, 2005). Decision matrices, SWOT analysis, force field analysis (Jonassen, 2012), advantage-disadvantage assessment, analytical hierarchies (Baker et al., 2001) are some of these tools. For the decision-making process that may be considered to end with the “*choosing an alternatives*”, Lunenburg (2010) has included two more steps being "*implementing the decision*" and "*evaluating decision effectiveness*". Depending on the results of their choice, the person has the opportunity to evaluate their success in the activities they perform during the process (Ratner & Herbst, 2004). In this way, even the decisions that are concluded negatively can be turned into an achievement for the decision making process that will continue during lifetime (Gauld, 2005; Raeva et al., 2011).

The data obtained through these interviews were analyzed qualitatively. In the analysis process, naming is made for each Science Teacher (as an example, the first teacher was renamed as ST1). The opinions of each ST are transferred to the computer environment, and the answers of the teachers are read separately by two researchers. Each teacher’s answer sheet was read separately in order to code the potential concepts and thematic structures in short and the coding process was based on either just words or whole sentences (Bogdan & Biklen, 2007; Gay, Mills & Airasian, 2006). The data analysis is predicated on the reflection of the decision-making process steps based on the normative decision theory of the teachers. The decision-making process consists of the steps such as *identifying the problem, generating alternatives, evaluation alternatives, choosing an alternative,* *implementing the decision* and *evaluating decision effectiveness*. As the implementation and evaluation steps of the decision are suitable for evaluation in the longer term, the process is considered the first 4 steps. After the opinions of the teachers are read by the researchers, it is discussed in which steps of the decision-making process the included opinions will be taken under consideration.

Table 1. Partial framework for evaluating teachers' opinions according to the steps of the decision-making process.

Steps of decision making process	Related findings
Identifying the problem	Information on nuclear power plants
Generating alternatives Evaluation alternatives	Expressing the aspects of nuclear energy and nuclear power plant related to positive / negative aspects and making explanations
Choosing an alternative	Teachers' decisions and justifications based on their decisions

In order to *identifying the problem* of the decision-making process, the definitions of teachers in relation to nuclear energy are taken under consideration in three different categories being insufficient, partially sufficient and sufficient. These criteria were created by the researchers based on similar structure in the study of Öztürk and Yenilmez Türkoğlu (2018). In this context, the criteria used in making the insufficient, partially sufficient and sufficient classification are presented in table 2.

Table 2. Criteria for evaluation of teachers' definitions in relation to nuclear energy.

Evaluations	Criteria
Insufficient	Not responded, no scientific explanation, completely wrong description or use of a faulty example
Partially Sufficient	Descriptions such as generating energy from nuclear material, generating energy from the atom (without describing how it is generated, without using scientific language)
Sufficient	Benefiting from the energy that arises while splitting the nuclear materials or descriptions related to the power plants' working principle through different descriptions having the same meaning (using scientific language)

The definitions of the teachers are subjected to descriptive analysis by the two researchers, and their descriptions are evaluated based on the criteria presented in Table 2. The reliability of the data analysis was calculated by using Miles and Huberman (1994) proposed formula (Reliability of the data analysis= [Same opinions / (Same opinions + Different opinions)]). For the reliability of the data analysis, the two researchers' opinions and differences of opinion were determined and the reliability percentage was calculated as 91%. Then, researchers compared the results of the analysis and then interpreted together, then a specialist who has researchers on nuclear energy examined the latest version of the analysis that presents the teachers' descriptions and in which table they are classified, and the analysis process is completed.

Themes are *determined by taking into account the science*, *policy*, *economy*, *society*, *ethics* and environmental aspects (Chang Rundgren & Rundgren, 2010) of the SSIs presented in Figure 1 to assess the teachers' awareness of the positive / negative aspects of nuclear energy in the process of creating alternatives in the decision-making process.

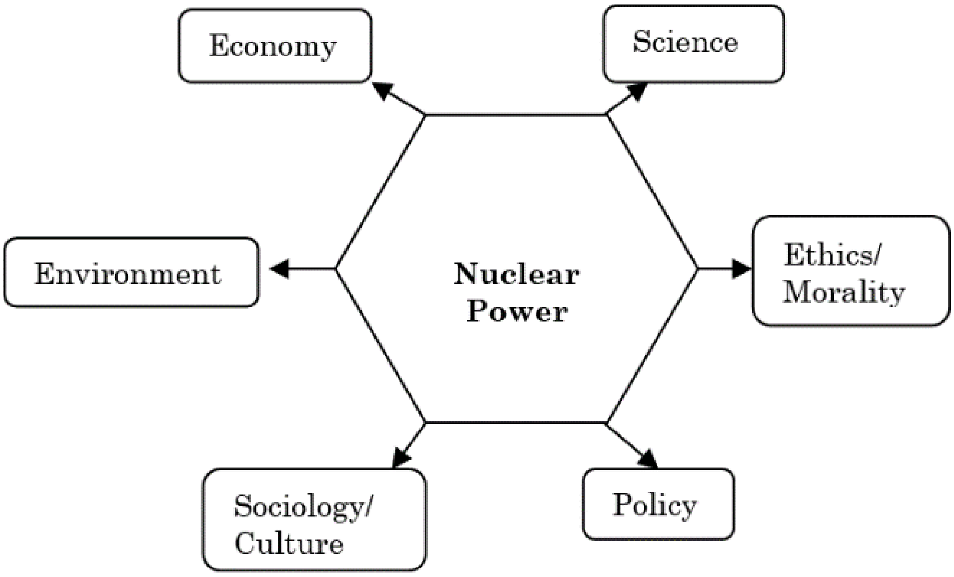

Figure 1. Aspects of socio-scientific issues

Sample codes for this analysis are presented in table 3.

Table 3. Sample code and descriptions.

Dimension	Code	Sample views
Social	Health	*"The positive side of the nuclear is the generation of energy, but it has higher risks. Even in the case of a leak at the minimum level, it may endanger the human health"* (ST1)
Economy	Development	*"Think about it we will cover this much of energy deficit, we will generate cheaper energy, and it seems like a must in order for the country to gain power..."*(ST21)

The teachers' decision expression *that are defined as positive for establishment of the nuclear power plant or negative* for establishment of the nuclear power plant and their justifications in relation to *these* decisions are taken under consideration in order to evaluate the alternatives of the decision making process and the data in relation to the steps to determine the most suitable alternative. Two different researchers have examined the emphasis of the teachers regarding the related dimensions about SSIs in their decisions and justifications. For the reliability of the data analysis (according to Miles and Huberman, 1994), the two researchers' opinions and differences of opinion were determined and the reliability percentage was calculated as 96%.

Limitations

The research is limited to those teachers who have experience on the socio-scientific issue of the nuclear plant that is planned to be built in Sinop, Turkey. An interview was made to reveal the decisions of the teachers about the nuclear plant socio-scientific issue and an interview form was prepared. Interview form is designed to determine the resources that teachers apply when making decisions about their definitions, decisions and reasons in relation to nuclear energy. The questions contained in the form were asked to the teachers and their decisions about nuclear plants were questioned in a general way. The socio-scientific issue about the nuclear plant was not structured within the context of a problem. The data of the research were analysed with the analytic decision-making perspective. Therefore, the findings are limited to the analytic decision-making perspective.

Ethical Consideration

Before starting the data collection process of the research, the teachers were briefed about the subject matter. They participated in the study voluntarily. The semi-structured interviews made with them were recorded with a sound recording device after obtaining their permission for this. The interviews were made in our environment where the teachers could express themselves comfortably. There was no one other than the researchers and the teacher being interviewed in the environment. The data of the research were kept where no one could access them. No one other than the researchers listened to the records. The names of the teachers were kept secret in the research process.

Results

The definitions of the science teachers about nuclear power plants, their opinions on the positive and negative aspects of nuclear power plants and their decisions on nuclear power plants and also the factors affecting these decisions are presented within the context of the steps of the decision-making process.

Identifying the Problem in Decision-Making Process: Findings on the Information of SSIs in Relation to the Nuclear Power Plants

The findings related to the definitions of teachers in relation to the nuclear energy and nuclear power plants are presented in table 4.

Table 4. The findings related to the definitions of teachers in relation to the nuclear energy

Code	Frequency (f)	Sample Descriptions
Sufficient	7 (ST2,ST3,ST4,ST10,ST14,ST19,ST20)	ST2: “"*...The nuclear power plant can be defined as the release of very powerful energy depending on the half-life of radioactive materials and the conversion of this energy into electrical energy…*” ST10: “*…It is generating electrical energy by evaporating the water using the high energy that is formed while splitting the radioactive materials and by covering it with high-pressure turbines …*” ST14: “*…It is the destabilization of the nucleus by bombing a very heavy atom with particle bombing. As a result, fission reaction is realized and ...turbines are turned, and electrical energy is obtained...*”
Partially Sufficient	15 (ST1,ST5,ST6,ST7,ST8,ST9,ST11,ST12,ST13,ST15,ST16,ST17,ST18,ST21,ST22)	ST5: *“…Generating electrical energy from atom energy...* ST6: *“…Power plants established for energy that is formed as a result of the atom nucleus reaction…”* ST7: *“…Generation of electrical energy as a fuel, by nuclear reactors. There will cause the generation of an unimaginably high energy at the instant. This will cause the generation of the energy with the vaporization of the water and the effect of the pressure with the help of the turbines...”*

The definitions of the STs in relation to nuclear energy are mostly evaluated as partially sufficient (f=15). For the definitions that are evaluated as partially sufficient, it has been found out that STs often include superficial explanations such as generating energy only from atomic energy or generating energy from nuclear materials. The definitions of some of the STs in relation to nuclear energy are considered to be sufficient (f=7). It has been found out that the STs the definitions of whom are evaluated as sufficient are able to give descriptions such as the energy released by the disintegration of nuclear materials, the radioactive materials used for nuclear energy and how the nuclear energy is converted into electrical energy and its distribution.

The Generation and Evaluation of the Alternatives in Decision-Making Process: Findings Related to Descriptions of the STs in Relation to the Negative and Positive Sides of the Nuclear Power Plants

Table 5 shows the opinions of the STs regarding the positive and negative sides of nuclear power plants and findings on which factors the SSIs are related, depending on the dimensions of the SSIs.

Table 5. Findings related to the positive/negative considerations of the teachers in relation to the nuclear energy

Theme	Code	Frequency (f)	Teachers	Sample Descriptions
Economy	Energy	15	ST1, ST2, ST3, ST5, ST6, ST8, ST9, ST11, ST12, ST13, ST16, ST18, ST19, ST21, ST22	ST2: *"The only positive side of the nuclear energy that I know is that it can generate a high volume of energy…"* ST7: *"…energy generation increases every day, but you still suffer from an energy deficit. I think nuclear power plants will solve this problem."*
	Cost	1	ST13	ST13: *"The most positive part of nuclear energy is I believe it is the most economical energy."*
	External dependence	8	ST5, ST9, ST11, ST18, ST19, ST20, ST21, ST22	ST9: "*By generating nuclear energy, we can become independent from foreign sources."* ST11: *"I think it is important because it will solve the ever-increasing need for energy and because it will prevent us to be dependent on foreign sources…"*
	Lifetime	1	ST12	ST12: *"The short lifetime of the nuclear energy will cause difficulties for us…"*
	Total	*25*		
Environment	Waste	10	ST2, ST3, ST4, ST9, ST10, ST14, ST16, ST18, ST20, ST22	ST3: *"…it is a very significant problem that the waste doesn't decompose for a long time…"* ST9: *"…the power plant will not accept any error, there are problems in storing the waste…"*
	Radiation	6	ST2, ST7, ST8, ST12, ST15, ST17	ST7: *"…radiation emitting risk of the radioactive materials and its negative effects on human beings and environment…"* ST12: *"…radiation emission…"*
	Destruction	10	ST3, ST4, ST6, ST7, ST10, ST13, ST15, ST17, ST19, ST20	ST6: *"…but it is necessary to consider a dangerous and a destructive possibility…"* ST13: *"…if attention is not paid, or if necessary measures are not taken, its harm to the environment will be so much higher…"*
	Total	26		
Sociology/ Culture	Health	7	ST1, ST2, ST7, ST15, ST17, ST19, ST21	ST1: *"Even in the case of a leak at the minimum level, it may endanger the human health."* ST7: *"Negative effects that it may cause on human health …"*
	Staff	4	ST10, ST11, ST17, ST22	ST11: *"…the fact that sufficiently equipped staff cannot be trained may cause negative results…"*
	Unsafe	3	ST5, ST9, ST16	ST5: *"…one of the problems is that it will not be secure. From various angles, it will be an unsafe power plant..."*
	Total	14		
Policy	Nuclear power	1	ST9	ST9: *"..to tell the truth, nuclear energy means power…"*

A large part of STs has discussed their views on the positive and negative aspects of nuclear energy regarding the environment (f=26) and economy (f=25) dimensions. STs made less frequent statements on social / cultural (f=14) and political (f=1) dimensions. The fact that STs can take nuclear energy under consideration through various dimensions shows that they can look at the subject from a variety of dimensions. It will be useful to address what they emphasize when explaining these aspects.

When taking the nuclear energy under consideration from an economic point of view, STs have made explanations related to its characteristics a solution which can meet the energy needs (f=15) and reduce the dependency on foreign sources in relation to energy (f=8), which has a high production cost (f=1) and which is long-lasting (f=1). Therefore, it is seen that they can look at the economy theme in a multi-faceted way. STs have dealt with their evaluations in the context of the environmental theme in terms of nuclear waste, regarding the fact that it may damage the environment (f=10), cause environmental damage by increasing the water temperature (f=10) and cause radiation emission in the region it is located (f=6). The elements they have taken into consideration under the social theme are the facts that it could threaten public health (f=7), that it could be dangerous for working personnel (f=4), and that they don't believe that the security (f=3) factors could be provided in our country. The ST who has considered the political dimension of the issue has pointed out that the nuclear energy will provide nuclear power (f=1) for the country.

Choosing an Alternative in Decision-Making Process: The Findings on Decisions of the STs in Relation to Establishment of a Nuclear Power Plant in Sinop

The considerations of the STs in relation to the establishment of a nuclear power plant in Sinop and the findings in relation to the justifications that they refer while expressing these arguments are presented in table 6.

Table 6. The findings about teachers' decision and the reasons for supporting teachers' decision

ST	Decision	Economy		Environment		Sociology/ Culture		Policy		Ethics/ Morality		Science	
		D	AD	D	AD	D	AD	D	AD	D	AD	D	AD
ST1	Negative	-	√	√	-	√	√	-	-	-	-	-	-
ST2	Negative	√	√	√	√	√	√	√	-	-	-	-	-
ST3	Undecided	√	√	-	√	√	-	-	-	-	-	-	-
ST4	Undecided	-	-	-	√	√	-	-	-	-	-	-	-
ST5	Positive	√	√	-	-	√	√	-	-	-	-	-	-
ST6	Negative	-	√	√	√	√	-	-	-	-	-	-	-
ST7	Negative	-	-	√	√	√	√	-	-	-	-	√	-
ST8	Negative	√	√	-	√	√	-	√	-	-	-	√	-
ST9	Undecided	-	√	√	√	√	√	√	√	-	-	-	-
ST10	Negative	-	-	√	√	√	√	√	-	√	-	-	-
ST11	Undecided	-	√	-	-	√	√	-	-	-	-	√	-
ST12	Negative	-	√	√	√	√	-	-	-	√	-	-	-
ST13	Negative	-	√	-	√	√	-	-	-	-	-	-	-
ST14	Positive	-	-	√	√	-	-	√	-	-	-	√	-
ST15	Negative	-	-	-	√	√	√	-	-	-	-	-	-
ST16	Undecided	√	√	√	√	√	-	-	-	-	-	-	-
ST17	Negative	-	-	√	√	√	√	-	-	√	-	-	-
ST18	Negative	-	√	-	√	√	-	-	-	-	-	√	-
ST19	Negative	-	√	√	√	√	√	-	-	√	-	-	-
ST20	Negative	√	√	-	√	√	-	-	-	-	-	-	-
ST21	Negative	-	√	√	-	√	√	-	-	-	-	-	-
ST22	Negative	√	√	-	√	-	√	√	-	-	-	-	-

ST: Science Teachers, D: Decision, AD: the dimensions that the teachers refer in relation to their positive/negative opinions about the nuclear energy that is taken under consideration as the development and evaluation of alternatives

In table 6, the approaches of each teacher related to the establishment of a nuclear power plant and the reasons presented in the arguments used in explaining these approaches are considered as the reasons that are effective in their decision-making. Table 6 also sets out the justification that each science teacher takes under consideration while evaluating the nuclear power plants (presented in Table 5). The purpose of this presentation is to make inferences about whether the reasons given by teachers in their evaluations are effective in their decision-making process.

While 15 of the STs have a positive understanding of the establishment of a nuclear power plant in Sinop, it has been found out that 5 are undecided and 2 have positive opinions. It has been observed that the justifications provided by the STs who have expressed their negative opinions for their decisions about the establishment of nuclear power plant do not coincide with the factors they have provided in their evaluations regarding nuclear power plants. 12 of the teachers who have provided a negative opinion (ST1, ST2, ST6, ST9, ST12, ST13, ST15, ST18, ST19, ST20, ST21 and ST22) have not taken into consideration at least one of the factors they have expressed in their evaluations on nuclear power plants. For example, ST1, while expressing his decision about the establishment of a nuclear power plant, declared reasons related to its environmental and socio-cultural dimensions. However, in their general evaluations of nuclear power plants, ST1 also has made evaluations concerning its economic dimension. Three of the STs who have provided negative views have considered all the reasons that they have stated in their general evaluations of nuclear plants also during their decision-making processes. In addition, these STs have included new reasons in addition to the ones stated in their general evaluations, in their decision arguments. For example, ST7 has added evaluations on the scientific dimension in addition to the environmental and socio-cultural dimensions that he/she has considered during their general evaluations. It has been found out that one (ST5) of the 2 STs who have expressed positive views on the establishment of a nuclear power plant in Sinop has considered all the justifications that he/she has discussed in his/her general evaluations also in his/her decision justifications, and that the other one (ST14) have not considered one of the justifications during the decision step but added an evaluation in relation to a new justification in his/her decision argument. 4 of the 5 teachers who have determined that they are indecisive related to the nuclear power plant issue (ST3, ST4, ST9, ST11) have not used all of the justifications that they have used in their general evaluations, for their decision arguments or added new justifications in their decisions. 1 teacher has used all the justifications from his/her general evaluations also in his/her decision arguments and also added a new justification in his/her decision argument.

Findings on the Resources that are Effective in the Decision-Making of the STs in Relation to SSIs

The findings of the resources applied by the STs during the decision-making on socio-scientific issues are presented in table 7.

Table 7. Resources used by science teachers in decision-making about socio-scientific issues

Theme	Code	f
Scientific	Scientific resource	15
	Scientific data	6
Media	Newspaper	8
	Television	8
	Social Media	5
	Internet	4
Environment	Friend	6
	Family	4
	Movement	1
Authority	Energy expert	4
	Scientist	3

Table 7 shows the resources that science teachers apply to make a decision, defend their views and refute a counter opinion. It is significant that most of the teachers' references that they apply while making a decision related to the nuclear power plant are scientific sources and numerical data (f = 15). In relation to this, T5 has stated:

> …generally numeric results or scientific studies such as reports, etc. that are published are more significant for me. When I make my decision, I especially try to consider the results of the scientific studies…", and also ST9 has stated "I can say that scientific sources have a more positive effect in terms of persuasion and decision-making in today's environment where there is a high volume of

> information pollution. While making a decision, I always have a hard time. Reading published studies give me the possibility to consider the subject under a different light. I think it is effective in my decision making. I can best refute someone's objecting ideas this way...

statement, shows that in decision making or in refuting a contrary view the scientific data are more effective. Some of the teachers have stated that they use media outlets (f = 8) and television (f = 8), especially the newspapers and television when deciding on the subject. ST11:

> I am always trying to catch the news hours. Or; as the nuclear is on the agenda, if there is a channel where this issue is discussed, I watch that channel, and there are generally programs that continue with a discussion. They give me an idea and definitely affect my decision making. Because in television programs they never gather people who have the same idea together. I like it better to listen to different views and synthesize these…

ST8 has stated:

> …even though internet and social media cover us from every corner, I always follow the daily newspapers. Especially if the issues on the front burner are discussed or considered, they take my attention so much more. For that reason, even though I prefer scientific resources and data while making a decision, newspapers also affect the people…

and tried to take under consideration the role of the media during decision-making. ST9 has stated in a similar way:

> In relation to the establishment of the nuclear power plant, I mostly read the scientific studies that are realized. It is an issue discussed on television programs, and there are mostly specialists in these programs.", I examine each of the two opinions. As it is not easy to make a decision on this matter, more than one resource is much more helpful. I will give an opinion to the people who don't think the same way as me following the resources where I got my information from.

and also provided some tips for the researchers and readers on how to refute the opposing opinion. Some of the STs (f=6) have stated that they are influenced by their friends' opinions under the environmental theme and emphasized the impact of the environment in their decision-making. Some of the STs have reported that an authority, for example, an energy expert (f=4), is effective in their decision-making process. ST7 has stated:

> Energy experts can provide more detailed information on the nuclear power plant. As it is their area of specialization, they can put forth the risk factors related to the establishment or non-establishment of the nuclear power plant. I consider this as an alternative in healthy decision making…

Discussion and Conclusion

The purpose of this research in which the decisions of STs in relation to the establishment of a nuclear power plant in Sinop, which is also a problem in their life, is studied is to study if the decisions of teachers in relation to nuclear power plant reflect normative decision-making. The knowledge levels of science teachers about nuclear power plants are mostly found to be sufficient. It is believed that the reason for this situation is the fact that the science teachers are familiar with the issue and have sufficient knowledge to formulate an opinion about it as they work in Sinop. Although the subject of nuclear power plant is consistent with the context of the daily life of the teachers and it is related to science, it is a noteworthy conclusion that science teachers' knowledge levels are most of the time partially sufficient. When it is considered that most of the science teachers have 15 years and more or 6-10 years of professional experience, it would be expected from the STs to have a higher level of information. However, various researchers have also found out that the knowledge level of pre-service science teachers on the subjects such as nuclear power plants and its working principle is insufficient (Eş, et al., 2016; Kapici & Ilhan, 2016; Özdemir & Çobanoğlu, 2008) Within the context of this research, this step is considered as the "*defining of the problem"* step of the decision-making process. In this step, it is important for the teachers to respond to questions such as "*What is nuclear energy? What is the operating principle of the nuclear power plants?"* As a matter of fact, in order to make evaluations about the nuclear power plant, first, they must have information in relation to nuclear power plants. As a matter of fact, it is important that students / individuals have awareness and content knowledge about the SSIs in the decision-making process (Tekbiyik, 2015). During the definition step of the problem, the in-depth examination of the problem is significant in obtaining the best solution (Lunenburg, 2010). At this step, which is considered as a step of defining the problem of the decision-making process, it is determined that teachers do not have an in-depth knowledge of nuclear power plants.

In "*generating alternatives*" and “*evaluating alternatives*” steps of the decision-making process, it is expected from the STs to make determinations related to the negative and positive aspects of the nuclear power plants and make evaluations in relation to these factors. Science teachers evaluated the nuclear power plants socio-scientific issue mostly with their *economic* and *environmental* dimensions. It has been found out that the evaluations made with economy dimension have different justifications such as energy, cost, external dependence and lifetime. It has also been found out that they can make determinations based on various reasons such as danger that would be caused by the wastes, environmental damage and radiation that the wastes would generate. It is possible to state that they have a multifaceted point of view in the economy and environment dimensions. On the other hand, science teachers made evaluations on social/cultural justifications less frequently. They have described these evaluations with the dangers and safety reasons against the public health and the personnel. Only one teacher has provided political considerations in his/her evaluation in relation to the nuclear power plants. The fact that STs can assess the nuclear power plants issue mostly through its economic, environmental, social/cultural dimensions suggests that they can take it under consideration partially through multifaceted aspects. As researchers realized with science teachers are limited (Kenar, 2013; Lee & Yang, 2013), conclusions of a few studies realized with the teachers and pre-service science teachers that are known as the closest working group are similar to the conclusions of these researchers. Lee and Yang (2013) have found out that technology teachers in Taiwan mostly do not support the construction of nuclear power plants in Taiwan and they prefer to benefit from clean, renewable energy sources such as wind and sun. In the research, it has been found out that the teachers have cited the accident in Fukushima and the threats to the environment as justifications. In the research realized with pre-service science teachers by Atesanderson and Saracoğlu (2013), it has been found out that most of the pre-service teachers have positive thoughts in relation to nuclear energy in terms of generating electricity and energy and providing prestige. It has been concluded that the pre-service teachers who have negative considerations about nuclear energy have provided apprehensive answers because of problems such as possible serious accidents, cancer and radioactive leak. In the research that they have realized with pre-service science and social studies teachers, Kapici and Ilhan (2016) have concluded that the pre-service teachers with a positive point of view in the establishment of the nuclear power plant have made this decision because of the generation of high volume of energy, and the pre-service with a negative point of view in the establishment of the nuclear power plant have made their decision because of the fact that radiation emission will trigger global warming.

Socio-scientific issues include dimensions such as economics, environment, social/culture, policy factors and also ethics/morals and scientific explanations (Chang Rundgren & Rundgren, 2010; Kolstø et al., 2006; Ratchliffe & Grace, 2003). In this case, the notable result of the study is that the science teachers did not consider the scientific dimensions during their evaluations. The fact that STs can assess the nuclear power plants issue mostly through its economic, environmental, social/cultural dimensions suggests that they can take it under consideration partially through multifaceted aspects. On the other hand, it can be said that these are the details of their evaluations within these dimensions. It is believed that the reason for their detailed evaluation especially with these dimensions can be the fact that they approach to this problem that they face in the province they live more in terms of the issues that will influence their lives.

In "*choosing an alternatives"* step of the decision-making process, the teachers have been asked to express their decisions and justifications in relation to the establishment of a nuclear power plant in Sinop. It has been found out that the STs' decisions in relation to the establishment of a nuclear power plant in Sinop are mostly negative, less frequently indecisive, but there are also teachers who have positive points of view. It has been found out that the arguments used by the STs in expressing their decisions don't completely coincide with the justifications that they have stated in the *"generating* and *evaluating of alternatives*" step. In other words, all of the justifications taken under consideration by the teachers in their evaluations related to the issue have not been effective in their decision-making process. Another conclusion is that even though it is in a small number, teachers have included different justifications during their decision-making step, in addition to the ones that they have taken under consideration in the evaluation of alternatives step. Supports this result, Jho et al. (2013) was to examine the relationship of students’ understanding of science knowledge, attitude and decision making on the issues of nuclear energy in Korea. Based on the results it was founded, students’ understandings of science knowledge were significantly improved throughout the instruction. However, they maintained similar attitude and decision making on the issue. Regarding the relationship of the three domains, attitude showed some degree of connection to decision making whereas science knowledge did not show a significant relationship to decision making.

It is possible to understand the reasons behind the individuals' decisions about the SSI through theories directed at the decision-making process (Wu & Tsai, 2007; 2011). For the individuals who are faced with the SSs, which by their nature allow the operation of decision-making processes, their previous experiences, practices or mental models will influence their decision-making (Fang et al., 2018). In this research, it has been found out that the fact that the science teachers' justifications that they have taken under consideration while presenting their decisions in relation to the nuclear power plants don't coincide with the justifications that they have taken under consideration while making evaluations in relation to the matter shows that they cannot reflect the normative decision-making process in their decisions. This conclusion can be interpreted as the teachers making a decision in relation to SSIs are affected by different factors other than knowledge. As a matter of fact, teachers who have been able to evaluate the positive aspects of the issue have been able to ignore these justifications while making their decisions. The normative decision-making theory considers the decision-making process as an analytical process that starts with the definition of the problem and ends with the decision (Germeijs & De Boeck, 2003; Kortland, 1996). Chang Rundgren and Rundgren (2010) draw attention to the fact that decisions on SSIs are influenced by values and personal experiences other than knowledge. While Fleming (1986a) emphasizes the importance of personal experience in decision-making in relation to SSIs; Fleming (1986b) and Bell and Lederman (2003) consider the importance of ethics/morals in the decision-making processes of the individuals in relation to SSIs. Albe (2008) has taken under consideration the importance of personal experience, knowledge and values during the decision-making process and stated that epistemological thoughts are effective in decision-making. Kilinc et al. (2013) stated that the reliability of information sources, the evaluation of the data, the values, prejudices and the cultural variables are effective in the decision-making process. However, *developing decision-making skills* which are one of the purposes of science education, science teachers will have to consider applications that take under consideration the socio-scientific issues. In this case, the teachers will be expected to structure the education process in a way which will require analytical decision-making. A significant factor that should be taken under consideration here is that the participants' views related to SSIs such as chicken meat, abortion, nuclear power plant, consumption of GMOs can be studied through questions like "What do you think about the nuclear power plants?". "What do you think about the nuclear power plant? What are your thoughts on the establishment of the nuclear power plant?". These generic expressions are surely directed to the participants who have sufficient information to make interpretations on the issue. In class applications, students consider the issue from different angles, and they are expected to make a decision following a discussion. But, when these issues are taken under consideration in terms of the definition of the problem step which is the first step of the decision-making process, they are very generic issues where it is difficult to draw a line. The good definition of the problem statement is significant in making an analytical decision. Hence, while making a decision, the factors that are presented in the problem should be taken under consideration. When we take the nuclear power plant issue under consideration, it may make a contribution to operate the decision-making process, to present data such as the yearly energy need of our country, how much of this energy could be obtained from which resources, production costs of the renewable energy and nuclear energy and also providing data for the other dimensions and to provide the significance of the criteria in this direction, while presenting the economic dimension of the problem statement. As a matter of fact, it is possible to propose the configuration of the problem statement related to the SSIs in order to lessen the effect of the factors such as, lives, values and mental models of the individuals that will prevent the analytical decision, on the decision-making process.

The results of this research also cover the fact that when STs need to make a decision on socio-scientific issues, the resources that they apply are mostly scientific resources, media resources such as newspapers, TV and social media, friends or authorities in relation with the issue. The access of the STs to the information through accurate and reliable resources will affect the decision-making process. The fact that they prefer to access the information through resources other than scientific ones, such as newspaper, TV, social media and friends provide clues in relation to the factors that affect their decision-making.

Recommendations

For future researchers, it can be suggested to examine the processes that are implemented through problem statement in which SSIs are presented with structure or without structure. In addition, more detailed findings can be reached by asking the teachers why they do not include the arguments in the decision of the factors mentioned during the evaluation of the alternatives. It is possible to discuss the suitability of teachers' classroom practices in developing students' decision-making skills by conducting researchers with a focus on how teachers are taking the SSIs under consideration in their classroom.

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Concept Teaching in Science Classrooms: A Critical Discourse Analysis of Teachers' Talk

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Abstract

Studies on science education stress that, in terms of discourse, teachers need to carefully build their understanding of science, language, and authority to better enable students to be successful in their science learning. However, the question of how much attention should be paid to this discourse, particularly for primary and middle-school students, remains controversial. This study examined the discourse of two teachers, who teach science at the primary and middle- school levels in different locations of Turkey, during concept teaching. The teachers' ideological structures related to social and pedagogical domains were analyzed through critical discourse analysis. The results revealed certain differences between the discourse of the teachers who teach at the primary and middle-school levels. Several factors, such as the patriarchal structure of the society and curriculum, lie at the bottom of these differences.

Introduction

In today's world, a great degree of emphasis is placed on science teaching, and the effectiveness of science teaching requires that teachers have a deep understanding of science concepts and their precise meanings. Many studies have indicated that students often stand aloof from science education due to their misunderstanding of scientific topics (Başer & Çataloğlu, 2005; Layng, 2013; Tezcan & Salmaz, 2005). In other words, one of the basic problems afflicting science education is students' lack of basic conceptual understanding regarding science. According to Tobias (1990), a vast majority of students do not like science because teachers tend to focus strictly on teaching facts, without showing any of the connections that exist between these facts, which results in them essentially overlooking big ideas. Furthermore, traditional applications and central exams are largely aimed at measuring how well students memorize the knowledge they possess, which leads to both primary and middle-school students being overwhelmed with unnecessary details, and the science lessons that furnish the students with the details are carried out in an uninteresting and non-inquiry based manner.

The same approach is mostly utilized in concept teaching, where each of the concepts is analyzed, and rational representations, which portray or do not portray the related concept, are made. In this way, a cluster of fragmented ideas ends up being created in students' minds (Layng, 2013). However, many of the schools and teachers that employ traditional approaches focus on a set of behavioral requirements for each course, introduce step-wise instructions to their students, and define concepts in an explicit way (Olson, 2008). Yet it is important that the students, rather than deal with only the details of concepts, examine the big ideas regarding the related concept and focus on the concept in this way. By doing this, teachers can better ensure that their students apply creative ways to understand concepts. This study aims to investigate the discourse used by teachers in concept teaching for science education in Turkey, and to determine the approaches they apply. In order to analyze the differences in discourse during concept teaching, an elementary school teacher and a science teacher, who teach science at different levels, were selected. One female teacher and one male teacher who teach at different locations were chosen, and their discourses were investigated at certain designated stages. However, the teachers' development within the process was not taken into consideration.

Literature Review

Concept Teaching in Science

Rosch (1999) defined concepts as the mechanisms individuals use to identify certain objects and asserted them to be open systems that students use to define new situations. von Glasersfeld (1995), on the other hand, characterized concepts as individual constructs to which mental images responsively yield via available perceptual cognitive material. Schill and Howell (2011) indicated that in science learning, particular attention should be attached to conceptual learning to enhance students' understanding, and they applied a "conceptual lens" approach to achieve this. With this approach, students examine their thoughts and express them in scientific ways.

For children, the learning and internalization of scientific concepts are viewed as a process. Freitas and Palmer (2016) mentioned that students can internalize this process by relating it to materials. Vygotsky (1987) investigated the concepts students use under two different categories: concepts they use in daily life and scientific concepts. This investigation was able to identify how scientific concepts are used and how the understanding of them can be improved in the early childhood period. With this information, Vygotsky intended to show and explain, using a dynamic methodology, that concepts are part of an extensive system. Dynamic methodology involves explaining the concept expression by conferring sense and thought onto objects. In essence, the concepts children use regarding daily life are obtained instinctively as a consequence of their immediate relation with the world. Green (1964) stated that education, in contrast to "teaching", can sometimes serve as an adequate tool for inculcating barbaric behavior. This is because teaching is an action that requires the expression of human behavior, and the discourse teachers use plays a decisive role in their teaching.

Discourse Issues

Discourse is a concept that can have various explanations, depending on the approach applied. While some researchers believe that discourse refers to all actions involving speech and writing, others consider it as actions involving speech network derivatives (Potter & Wetherell, 1987). In different periods of time, humanity has worn different masks, and therefore, discourse differs by time periods (Parker, 1992). van Dijk (1997) discussed discourse according to daily-use language, arguing that it includes special and general speech-language, as well as the various shapes and forms they come in. Starting from the 1960s, discourse analysis, which began to be defined outside of its relationship with language, has become an interdisciplinary study domain. Within this new framework, discourse studies have involved different areas, such as text, speech, communicative action, film, and/or picture (van Dijk, 2007). Discourse analysis, which is included in the social structures required by recent educational approaches and is used to explain learning, has become an alternative theoretical perspective (Gee & Green, 1998).

This diversity in the use of language led to the rise of different views regarding the analysis of discourse. Some scientists have put forward specific types and sub-branches or different methods –which are closely related approaches– of discourse analysis (Phillips & Hardy, 2002). One of these methods was critical discourse analysis (CDA). The critical aspect of discourse analysis emerged in the 1970s, at which point discourse began to be defined on critical grounds. The work, Language and Control, written by Fowler, Kress, Hodge, and Trew (1979), was particularly pioneering, in terms of giving discourse studies a critical component. Critical discourse analysis is an approach that focuses on the investigation of the political and social contexts constituting discourse. In terms of their critical dimension, discourse studies introduce a rather broad conceptual and methodological framework, one that includes identity, awareness, and other elements (van Dijk, 2007). Discourse can be regarded as a structure that contains and systematically reproduces different power and authority relations. In terms of both structural and functional content, CDA is used as a method applied to investigate the relationship between authority, discourse, and action. This approach is regarded as a multidisciplinary analysis method that largely focuses on the language itself and the context wherein the language is used (Fairclough & Wodak, 1997). Considering the functional and structural characteristics of the discourse together is among the priorities of CDA. CDA differs according to the discretion of the researcher performing the analysis, and concepts like discourse, criticism, ideology, and power are used with very distinct approaches. For this reason, CDA can be primarily regarded as a school of thought or as a program (Weiss & Wodak, 2003). In the application of critical discourse analysis, the primary aim is to determine whether there is a need for a meta-theory for the interpretation of the meaning that constitutes the discourse or that is inferred from the discourse, and how to form the conceptual framework that is needed within the context of the content and the core of the problem (Weiss & Wodak, 2003). Therefore, this study followed an interpretative perspective within the context of the content and research problem. In general, CDA attempts to understand the role of language, as a social tool, in terms of the social interactions within society, power dynamics, power distribution, institutions, and the formation and sharing of knowledge. In seeking to achieve this, CDA investigates how language mediates and provides a basis for determining power relations, benefits, and priorities (Gee, 1999).

Purpose

The aim of this study is to investigate CDA of the primary school teacher and science teacher who teach in science classroom. For this purpose the following research questions have been addressed.

1. How are the primary school and middle school science teachers';
   a) Discourse for in-class climate and cultivating a love of science,
   b) Motivating discourse,
   c) Discourse for the use of language in science classroom?
2. How is the primary school teacher and science teacher's discourse associating science with daily life and concept teaching in science classroom?
3. How is the primary school teacher and science teacher's towards students,
   a) Discourse in gender issue,
   b) Discourse in authority and power issue in science classroom?

Method

Discourse Analysis

Critical discourse analysis was used as the methodology in this study. Discourse analysis, a perspective that concerns social life, consists of methodological and conceptual elements and is characterized as a way of perceiving the discourse and transforming it into data. Discourse analysis is carried out independently of the general, theoretical, and quantitative approaches and it functions as a transition to detailed and qualitative approaches (Wood & Kroger, 2000). In the last two decades, sociocultural theory-based discourse studies have grown to be more common in the effort to understand learning and teaching in social settings (Gee, 1999; Wertsch & Toma, 1995). These studies involve analysis techniques that are developed by feeding off different disciplines and those feature restrictions based on the theoretical perspectives of these disciplines (Potter & Wetherell, 1987; Tonkiss, 2004). According to Elliot (1996), criticism is at the center of discourse analysis, is used to reveal how social groups or individuals use language in order to attain power or to disseminate their ideological opinions. According to Kress (1990), CDA is a radically different type of linguistics, one that is based on certain assumptions.

"These assumptions include the ideas that language is a social phenomenon; that, not only individuals but also institutions and social groups, have specific meanings and values that are expressed in language in systematic ways; that texts are the relevant units of language in communication; that readers/hearers are not passive recipients in their relationship to texts; and finally, that there are similarities between the language of science and the language of institutions" (Wodak & Meyer, 2001, p.6).

CDA achieves the objectives of investigation by revealing the social relations and identities existing in society on the basis of written and verbal texts (Luke, 1995). From this point of view, van Dijk (2003) explained the various purposes of discourse analysis as follows: In case studies, CDA should be better than all other marginal studies in order to be approved by all other marginal research methods. It should focus largely on social and political problems, rather than on existing paradigms and wordings. The critical analysis of the experimental competency of social problems should generally be conducted in a multidiscipline manner, and CDA should attempt to explain discourse structures on the basis of the social structure and the level of success in social interactions, rather than only describe and clarify discourse structures. CDA mainly focuses on the legalization, validation, legitimization, transformation, and restructuring of the power and authority relations in a society, or the challenging of them.CDA starts out by relating a social problem to the language in which it belongs to or other semiotic aspects. The actual analysis is initiated with the framing of the sociocultural applications within the text where this social problem is present. "This analysis of the social practice(s) surrounding the discourse practices under question includes identifying the relationship that exists between the discourse and other aspects of the social practice" (Hanrahan, 2005, p.14). Fairclough (2003) set forth three inter-related dimensions: a) text dimension, b) discursive practice dimension, and c) social practice dimension. The analysis of these dimensions is carried out in the form of linguistic and semiotic analysis and an inter discursive analysis, both of which are then related to each other (Hanrahan, 2005). According to Gee and Green (1998), discourse can never be objective, as they necessarily reflect a particular ideology, value system, or belief. Therefore, the entire text subject to the CDA should be analyzed at the micro, intermediate, and macro levels encompassing almost all social contexts. At the micro level, the teachers' word-related semantic, linguistic and phonological applications are analyzed, while at the intermediate and macro levels, the cultural, institutional, and textual structures generally governing the text are analyzed (Hanrahan, 2005). Despite being seemingly carried out in different contexts, the entire analysis is performed in an interrelated fashion, based on a specific philosophy. The main goal in CDA is to identify the ideological process presented in the discourse and to attempt to understand from the text the structural characteristics that the individual involved in this process possesses (Fairclough, 2003). That is to say, with the CDA, the discourse structure should be understood, considering that the CDA particularly looks for clues to how the ideological discourse is expressed in the text, the presence of any assumptions that may have been overlooked, and social structures. This is because teachers who are teaching in science classrooms will either consciously or unconsciously provide certain clues related to concept teaching.

Participants

In this discourse study, generalizations were derived from the data obtained from the discourse of two teachers who were teaching during the spring term of the 2017–2018 academic year in Turkey. David (pseudonym), one of the participants, is an elementary school teacher who has been teaching for 10 years in various public schools. David expressed his role as a teacher as follows: “I am a teacher who performs what my occupation requires. I consider myself competent in science teaching. The children show a great interest in experiments. I work with great devotion, using my experiences.” He added that elementary school teachers in Turkey are reluctant to participate in the professional development training provided to them because they consider this training useless. He said that he actively uses various instructional materials (newspapers, microscopes, educational videos, and other sources to supplement the textbook) in the classroom environment. He believes that students can better learn science concepts by utilizing the trip-observation method and expressed that he performs most of his teaching in out-of-classroom environments. His school is located in a small village, where the classroom has a total of 10 third-grade students. Carla (pseudonym), the other participant, is a science teacher who has been teaching for six years in various public schools. Carla defined the role as a teacher as follows: “I am a teacher who innovative, closely follows scientific developments, can comfortably communicate with the students, and believes in discipline same time I consider love as the most essential component in education.” Carla is a very active teacher and enthusiastically strives to fulfill the tasks assigned to her by the administrative board of the school. In her science teaching, she believes that she can learn something from her students. Carla works in a big school located in the city center and teaches science to students at middle school level. In this study, Carla’s lessons with sixth graders were observed.

Data Collection Process and Analysis

After determining the purpose of the study, an elementary school teacher and a science teacher, who teach at different locations, were interviewed for the purpose of data triangulation. Other data sources are video recordings and all kinds of documents used by teachers in the course. After both teachers were informed about the purpose of the study and permission to conduct a video recording of their lessons was requested, they agreed to take part in the study. Video recordings were carried out for seven lesson hours for David and for five-lesson hours for Carla. Since the researcher was not able to be simultaneously present in the two classrooms at the same time, video recording devices were placed in the classrooms. The cameras were left on for two weeks, but the recordings obtained within this period were not taken into consideration, as the purpose behind leaving the cameras open was to familiarize both the teachers and the students with the presence of the camera in order make them comfortable expressing natural behaviors and discourse. Following the video recordings, an approximately 30-minute interview was conducted with the teachers. The interview included questions on the teachers’ applications in the classroom and the justification of these applications.

The raw data obtained from the video records and the interviews were transcribed onto a form. This form included approximately 120 pages. The non-verbal data were then added to these data. As part of the first stage of the study, all the data obtained from the data collection tools were read several times, while the visual data and interview data obtained were analyzed using Jeffersonian system symbols[*] (Atkinson & Heritage, 1984). Since the computer software, which can create images and transfer audio records into a written format, did not work for the Turkish language, the entire process was carried out manually. The transcription process took more than two months to complete. In order to facilitate the analysis process, the researcher applied different symbols which were unique to this study, in addition to the Jeffersonian system symbols. At the stage of microanalysis,

[*] Jeffersonian Transcription Notation includes the following symbols: Brackets, Equal Sign, Timed Pause, Micro pause, Period or Down Arrow, Question Mark or Up Arrow, Comma, Hyphen, Greater than / Less than symbols, Less than / Greater than symbols, Degree symbol, Capitalized text, Underlined text, Colon(s), High Dot, Parentheses, Double Parentheses. All of these symbols have a function in the text.

the recordings were transcribed in written form and once again reviewed to confirm that the recordings and written transcription were in perfect correspondence. This was done in part to fulfill the purpose and targets of the study. Specifically, the microanalysis examined those paragraphs indicating the manner in which the teachers formed their respective in-class climate, how they cultivated a love for science in their students, and their motivating discourse. In the analysis of micro-level data, other themes, like misconceptions of the teachers, their understanding of the status quo, and curriculum emphasis, emerged. These sub-themes were described with examples. Since the focus of the study was the teachers' discourse, the students' conversations were not taken into consideration. However, no special effort was made to remove the students' conversations from the video recordings. Nonetheless, though the focus was strictly on the teachers' discourse, the fact that the students' conversation, as well as the physical and psychosocial characteristics of the environment, may have influenced the discourse of the teachers was clearly understood in this study. The entire text was analyzed based on the three-level CDA analysis process, as specified by Fairclough (1989). According to this, the first stage (the description stage) includes a comprehensive analysis of words, grammatical features, and assumptions – in other words; the vocabulary –where the focus is on the stress of lexical components and other metaphorical meanings. The second stage (the explanation stage) involves the analysis of ideological structure and practices in the social and pedagogical contexts. The last stage (the interpretation stage) involves the interpretation of both stages.

Credibility

In this study, CDA was applied to identify the structure of discourse used by David and Carla during concept teaching. Several techniques were used to secure the reliability of the study. As in all qualitative approaches, before using the visual images obtained from the teachers and the written form of the interviews, they were first presented to the teachers to get their interpretation and evaluation of the data. Following this stage, the opinions of two additional researchers, who were experts on the methodology of qualitative studies, were consulted about the suitability and comprehensiveness of the themes and the coding derived from the written forms. The fourth-generation evaluation techniques proposed by Guba and Lincoln (1989) were used to confirm the reliability of the study. The first of these techniques involved long-term interactions with the participants. The researcher spent great lengths of time with David and the students in the classroom to help establish an environment of trust between him and the classroom, while in the case of Carla and her class, weekly meetings were performed, where the students identified the researcher as a teacher from a different school, to help establish this same sense of trust. These efforts at building trust in both classrooms provided a considerable advantage, in so far as they made the taking of audio recordings and field notes easier, which allowed for the research questions to be answered in a progressively simpler way**.**

Results

The Primary School Teacher and Science Teacher's Discourse in Science Classroom

David: David is an authoritarian teacher in his classroom. His students never intervene during his speech, and they pose their questions only after being allowed to by him. Physically, David is quite tall and strongly built. He always walks around the tables in the classroom and attempts to be in the driver's seat. When students are allowed to speak, they do so in a loud and clear voice, but other than that, there is hardly any noise in his classroom. The control of the classroom is completely under the authority of David, and activities are carried out based on the textbook. David constantly warns his students that they need to raise their hands if they wish to speak. For learning subject items that David deems important, he asks his students to repeat the related sentences, and he writes notes about these items on the board, telling his students to note them down in their notebooks at the end of the lesson. His speech is clearly understood in the classroom, and all of the students listen to him attentively. He generally talks in a loud manner in his classroom and distinctly enunciates his words. He also repeats loudly the answers to the questions he poses to his students.

Carla: Physically, Carla is average-sized, and she speaks quickly and loudly. In her speech, she repeats the words her students speak. On the issue of word choice, she focuses on technical words and avoids using daily language. However, she presents examples from daily life in order to facilitate understanding in her students. She is very sincere in her communication with her students. When she wants to clear the board, she asks "Is there a gentleman or a lady who would like to clear the board?"At hearing this, the entire classroom gets excited, and every student begs the teacher to choose them, saying "Please teacher, pick me". Her students can easily communicate with her, and female students, in particular, participate more in the lessons. She also presents options to the students in the questions she poses and uses encouraging words to advance the topic to be presented and in doing so, expects the students to master the topic. Carla does not tightly adhere to the curriculum or the textbook but rather, requires her students to question her ideas and produce new ones.

Discourse for In-Class Climate and Cultivating a Love of Science

In examining the structure of David's and Carla's discourse, it was found that both teachers used social experiences and daily events to teach science. The discourse identified in the observations was corroborated by the interviews conducted with the teachers. David, in his interview, indicated that he frequently uses laboratory practices in order to garner the students' attention and to cultivate a love of science in them, and that he felt this was the best way to accomplish these goals. However, during the seven-hour-long lesson observation conducted in David's classroom, he never did a single laboratory practice and only assigned homework about growing beans and grass. Besides having his students watch ready-to-use videos on the interactive whiteboard, David never went beyond the textbook. While these videos did strongly appeal to the students, there was no continuity to them due to the failure to engage in any conversation about the videos, as the teacher was the only one who spoke in the classroom. In the interviews, David described himself as a teacher who is responsible for presenting and explaining the science to the class. Yet, David had some misconceptions about teaching science-related concepts, and since he was not aware of this, these misconceptions were transmitted to his students. The concept, "work-oriented classroom approach" introduced by Hanrahan (2005, p. 33) holds true for David, as he expected all his students to carry out and complete the same task simultaneously. The students were obedient to the teacher, never made any inquiries, never talked without raising their hands, and expressed themselves using only a couple of words. Although the students were primary-school third-graders (age 9), they were quite silent in the classroom and did not pose any questions stemming from their curiosity. They sat for 40 minutes and were expected to perform the activities they were assigned. Therefore, David, as he stated in his interview, does not purport to raise future scientists.

Carla presented a quite idealist teacher profile in her interviews. The lesson observations also revealed that she puts forth efforts to nurture a love of science in her students and helps them to acquire a strong knowledge of science. However, Carla's classroom was considered poor in terms of sociocultural and academic achievement. She had just started her new position at her current school, and the school has a different institution culture from what she was accustomed to. Carla strived to break the sense of failure and frustration that dominated the climate of her classroom and the school. Carla, in her discourse, would sometimes get angry with her students when they failed to conduct research. In response, she would assign them homework to encourage them to make inquiries, even on extracurricular topics. In addition, Carla did feel of pressure from the curriculum. On this matter, she said "We need to complete our topics as quickly as possible, and I hope that the students can practice solving problems using different materials". In the interview, Carla said that she wanted to focus on in-class and out-of-class activities; however, she hurries through topics due to the intense curriculum applied. She further indicated that she pays close attention to her in-class discourse to cultivate a love of science in her students. On top of that, she places great emphasis on national values and expresses this in her lessons, asking her students to think critically about socio-scientific situations to further nurture a love of science in them. In addition, Carla's students participate in the lesson, attempt to engage in discussion, and do not hesitate to ask questions about topics they are curious about. Despite certain disadvantages related to the approach, Carla's classroom can be partially regarded as a "learning community-oriented classroom" (Hanrahan, 2005,p.33), as Carla provides opportunities for her students to make mistakes and responds to all questions her students ask out of a sense of curiosity. She presents new and interesting examples to them (Wall-E, automotive engineering etc.). In the context of "learning community", Carla looks to additional applications to meet her students' personal and social needs. In striving to nurture a love of science, she gives examples relevant to the environment of the students, in such a way that demonstrates the role of science in daily events. Furthermore, she encourages her students to speak in the lessons, even if they make mistakes, and attempts to make them use the concepts by including them in the discussions.

Motivating Discourses

David generally displayed the characteristics of the stylistic norms of school science proposed by Lemke (1990), with the exception that he spoke in a clear, concise and calm manner and helped to facilitate his students' acquisition of daily life related to the meaning of concepts. However, this style did not seem to be effective in the students' use of concepts, partly due to the tendency of David to use sarcasm in his discourse. The students talk in a brusque, unassertive manner, using incomplete sentences when they are responding to a question posed to them on a topic. David sometimes laughs or pretends not to have heard questions posed by his students. His motivating expressions are mostly limited to "Come on, man", a street type of language. Carla's case is quite the opposite. When she cannot hear something a student has said she makes them laugh by saying "Children, I am old; I cannot hear your voice" and then proceeds to answer the question without any hesitation. Criticizing the disciplinary practice of writing the names of students who were loud on the board, she mentioned that the students need to talk and had no problem with that so long as it stayed within the framework of respect. From the interviews, it was made clear that Carla believes that students, particularly females, should be encouraged to participate in the lesson by giving them opportunities to talk.

Discourse for the Use of Language

In his lessons, David primarily gave the name of the concept related to basic terms and phenomena and asked his students what came to their minds when they heard this concept. The students would either give no response or make an explanation consisting of only a few sentences. In such cases, David would explain the concepts himself, speaking distinctly but with few words. This use of language can be considered as assistive in helping the disadvantaged students in his classroom understand the concept. However, these disadvantaged students did not participate in the lesson or react at all. Therefore, the explanation of the concept by the teacher prevented the formation of a dialogue environment in the classroom. Moreover, since there was no dialogue in the classroom, the misconceptions that the teacher had were transmitted to the students directly. Hence, this empowered the authority of the teacher in the classroom and served as a barrier to personal decision-making, making mistakes or self-expression, which are all necessary for the student. The students took no initiatives and showed no enterprise as a result of this controlling approach. Carla, on the other hand, used motivating sentences to encourage the students' participation in the lesson, expressed her appreciation when her students participated, and encouraged them to ask questions, wonder and conduct research. She kindly made requests using humoristic language and asked her students to also use kind language in the classroom. She provided feedback to the students' discourse on the concepts and did not accept one-word answers. In the case of David, it was clear that his use of discourse reflects the message that science has strict boundaries that must be adhered to and not be questioned, and that there is a single explanation for science-related concepts. The language and discourse David used is based on the idea that a concept should be expressed openly to students in order for them to adequately understand this concept. Carla, on the other hand, believes that science has an indefinite domain and should be questioned, and that students need to engage in discussion. In concept teaching, Carla, rather than explaining a science-related concept or directly introducing it to the students, asked the students to construct the concept on their own. She paid no mind to the concepts presented in the textbook and even went so far as to not look at how the textbook defined the related term. Based on this, it can be asserted that she, in the language and discourse she uses, directs her students to counter-ideological ideas that go beyond the standard patterns (unorthodox to the school culture).

A descriptive portrait of the discourses used by the two teachers was created in the manner as shown above in the excerpts presented for each teacher. In the following section, a presentation of this portrait is carried out, along with a discussion. Based on the nature of CDA, these portraits are investigated in terms of social context and their ideologies, as they relate to pedagogical discourse. David's and Carla's discourse have different structures in terms of the social context and the ideologies to which they subscribe. There were differences between the teachers as regards creating the in-class climate, cultivating a love for science in the students, motivating discourse, and the use of language.

The Primary School Teacher and Science Teacher's Discourse Associating Science with Daily Life and Concept Teaching in Science Classroom

David: During concept teaching, he primarily writes the name of the concept on the board and questions his students about this concept. However, there is no environment of discussion in the classroom. David constantly repeats the name of the concept and asks the students what they think about the concept. Students ask questions about the concept, and David presents explanations to these questions. At times, he starts a sentence and asks his students to complete it (T: Yes, that is to say, reproduction is … (Students say "increasing")). He uses almost no technical words. All the examples he is present in his lesson are from daily life and explains with spoken language. The data obtained in the interview conducted with David indicates that he is of the opinion that daily language is more suitable for learning science and that technical words have no meanings for some students. David tends to avoid talking in the form of written language; he inserts his personal judgments when he speaks; and he feels strongly that science can be learned through daily experiences. Investigating this situation from a linguistic perspective, it can be argued that teaching science in this way is not that impressive in terms of stimulating reactions from students. He uses textbooks only as a guide to carrying out the activities. He usually uses sentences in the present or future tense ("We do this now", "we will learn this", "we will apply" etc.). His conversation with his students is limited to a "triadic dialogue pattern" (Lemke, 1990). In other words, he only focuses on words during concept teaching and does not include other students in this operation. It is interesting that David's students do not, in any way, attempt to break this triadic dialogue template. Students speak either too little or not at all and raise their hands only to answer the questions David poses, and their answers to these questions never exceed a few words. David does not use any of the more recently developed applications in concept teaching activities, and he carries out the lesson in a monotonous manner. Furthermore, he does not present any review or important information at any point in the lesson to students who are new to his class. The topic of the day is consistently repeated at the beginning, middle, and end of the lesson. David presents all of the information in a ready-to-use manner, and since he has a small class, he supports individual studies. However, David applies a teacher-centered approach and often uses the question-answer technique. In all the seven lesson hours observed, outside of presenting a documentary or some other academic video on the interactive whiteboard occasionally, he generally directly taught the lessons himself. He uses the activities in the textbook but does not supplement them with other teaching methods, such as trips, observations, or experiments. When calling on his students or speaking to them as a class, he would alternately refer to them as "lady, master, my man", which are commonly used in the local language, or as "children", and "friends". He uses the term "assistant" to refer to the students who help him in his lessons. He occasionally talks with his students in street language. In adopting a status quo perspective in the classroom, he sometimes uses sarcastic expressions. In one lesson, where he wanted to demonstrate the relationship between the intensity of voice and the distance it travels from its source, he gave a book to one of his students and asked him to read it aloud. First, he asked the student to read the book aloud in the classroom and then told him to go to different places outside of the classroom (the school corridor, stairs at the gate of the school, and school garden) and continue reading aloud. In instructing the student to go out of the classroom, he told him "Come on, S2, go ahead, go, go" (@@@!!!). By doing this, he was demonstrating his authority (demanding that his students move in the way he wanted them to move), stressing the objective in an unquestioned manner, and reinforcing the status quo of the teacher-centered approach he applied in teaching science. Martin (1997, as cited in Hanrahan, 2005) termed this situation the "appraisal system", which means that the words and behaviors expressed to increase the status quo. This perspective that the teacher possesses was complied with by the target group, who demonstrated no conflicting behaviors and did not question the truth or challenge the teacher. According to Eggins (1994), this situation eventually leads to the person in power no longer needing to engage in a tour de force. On occasion, David would sometimes use impolite expressions. The excerpt below relates to a lesson David taught on the topic of "characteristics of living creatures", where the students said that the blue whale was the biggest animal in the world.

> T: Is the cheetah regarded as the speediest animal in the world? Cheetah. Yes, of course, if our interactive whiteboard opens ((He tries to open the interactive whiteboard)). Is this opened? ↑ Yeah!! ↑Yes. There were lions in the documentary we watched yesterday, weren't there? How were they hunting? <u>They were hiding</u> and immediately started to chase when their prey appeared, and they caught them straight away. Let's see how fast the fastest animal in the world is, let's watch.
> S2: My teacher, isn't the blue whale the biggest animal in the world ((The classroom gets stirred up))
> T: Yes, it is known as the weightiest animal in the world. What is its weight? Is there anyone who knows?
> S1: 30 <u>TONS</u>
> S3:40 <u>TONS</u>
> S6:70 <u>TONS</u>
> S10:80 <u>TONS</u>
> S9:45 <u>TONS</u>
> S1:300 <u>TONS</u>
> S7:1000 <u>TONS</u>
> S8:500 <u>TONS</u>
> T: Man, don't just throw numbers out there.

For the rest of the lesson, David presents a documentary on the fastest and the slowest animals in the world.

> T: Yes, a cheetah can reach a speed of 120 km per hour↑. That is to say, nearly <u>as fast as the speed of a car</u> ((He starts the documentary and the entire class watches)).
> T: Ohhh, do you see it? So, a rabbit can reach the speed of 75 km per hour ((In the documentary, the speaker says, "This bird, which is second on the list, can reach the speed of 150 km per hour." The

teacher whistles. And, here it is, the top of the list. The peregrine falcon is at the top of the list. This bird reaches a speed of 320 km per hour when it starts to dive. The teacher again whistles)).

In his effort to include students with special needs, David always shows them attention and keeps them in mind when giving examples for the subject being taught. The examples he shows sometimes arouse a laugh from the students and even from himself. Being fond of food, David often integrates something to do with eating into the examples he presents. When he wants to get the students' attention, he claps vigorously, and to create a relaxed atmosphere in the classroom, he walks around the room, rests a hand on the shoulder of a student, and jokes with them. When he gets the desired response from the students, he uses reinforcement, telling them "well done". Being tightly attached to the textbook, David, in one of his lessons, asked his students to grow beans and grass as homework. However, the students were not able to complete this homework assignment on time. It was determined, from the observations, that David has some misconceptions about certain science concepts.

Example 1: Natural and artificial light sources

When teaching the topic of natural and artificial light sources, David assumed cloud-to-ground and cloud-to-cloud lightning to be the same in terms of their formation and expressed this to his students in this way. In addition, he used the idea of fire to teach the event of electrification in the formation of lightning.

T: Who built the lighthouse?
Ss: Humans.
T: That is to say, it does cast light on its own.
S1: Lighting
T:Yes, lighting, isn't it? (.) It is natural. All right, how does lightning form?
S2: When clouds collide with each other, cloud-to-cloud lightning occurs. For this reason, lightning is also artificial.
T: Lightning, hmmm. Now, we said lightning is artificial, S1? What kind of a light source is lightning? Can humans produce cloud-to-cloud lightning or cloud-to-ground lightning?
Ss: Noooo…
T: NO, THEY CANNOT. What is cloud-to-cloud lightning or cloud-to-ground lightning? They are a natural light source. So, what happens is a fire appears on its own when two clouds collide with each other. And we call this cloud-to-cloud lightning or cloud-to-ground lightning↑. And, they are examples of natural light sources (2s). That is to say, children, natural light sources form on their own and occur in nature, completely without human intervention. All right, what are artificial light sources?
T: NO, it is its own light source. It comes with its own light. So, a meteor is a light source as well.

Later in the topic of natural and artificial light sources, David talked about meteors as a light source.

T: What do we call all of these things? We call them artificial light sources.
S3: My teacher, what do meteors do?
T: ((He is looking at a picture of a meteor in the textbook)) The one in your textbook?
S3: Yes, there it is; what is it?
T: Yes, this is a meteor. Actually, what was happening when we were watching the Ice Age movie? What was the meteor doing? It was approaching↑ but how was it coming from space? It was coming by firing, wasn't it? Can humans place a lamp, a light, or a battery in meteors↑?
Ss: No:::

In the following lesson, David opened a video on the interactive whiteboard that was related to the topic. He repeated what was said in the video and would sometimes pause the video to make additional explanations. On one occasion, he put forward the following explanations on the formation of night and day.

T: Why is the earth dark at night? ((He paused the video)). What is this? It is the result of the earth's rotation. The sun is stationary; the Earth rotates. As the Earth rotates, what happens to the part facing the sun?
Ss: Daylight.
T: Yes, daylight. The part which does not face the sun:::
Ss: Dark.
T: That is to say, when we say daytime, how does the light of the sun reach the Earth? Do the rays reach the Earth in a perpendicular manner? And, what do the sun's rays bring to the Earth? It brings

> light↑. However, since the Earth rotates at a slow pace, we gradually move towards darkness; that is, from daytime to nighttime.

Example 2: Sound and sound sources

In one lesson, David discussed the sounds humans can hear and played the telephone game in the classroom. He pointed out that they cannot hear the footsteps of ants or flies. David associated this situation with the size of our ears.

> T: For example, a fly comes and lands on the table; it moves on the table. Do you know in which direction it moves? (.)
> S5: But, we do not hear their footsteps, my teacher.
> T: We can hear the footstep of humans though. I wonder why? ((The students quietly think about this))
> S1: Because they are small, and we are bigger than them.
> T: Children, our ears do not hear all of the sounds in our environment; we cannot hear some sounds↑. Normally, ants, birds, bats, and insects produce sound when they walk↑, but the sound coming to our ears is not at a level we can perceive↑. We cannot hear these sounds. However, when a human talks, a dog barks, a car makes a noise, or an earthmover is operating, we can easily hear these sounds. For example, sometimes cars come quietly,↑ you cannot perceive them at all, and before you know it, it is just beside you; our ears are not adequate to perceive all sounds::: We cannot hear the sound of ants walking on the ground or the sound of bats; humans cannot hear the sounds of natural events or the sounds earthquakes make before occurring; however, dogs, since they can hear these sounds that humans cannot hear, react. What do dogs do? They bark (hhh). That is to say, they can hear the sounds we cannot hear. <If our ears were a little bigger>, we could hear more sounds; however, since our ears are always at the same level, we have difficulties to perceive certain sounds.

Later on in the lesson, David attempted to construct the relationship between the sound source and the distance; however, in doing this, he presented incorrect information about bats.

> T: Some animals in nature, for example, bats, can hear the sounds that we cannot hear, right?
> S6: Yes.
> T: What is one of the characteristics of bats?
> S3: They are blind.
> T: Yes, what is one of the characteristics of bats? They are blind. All right, based on what then do they move?
> Ss: Sound.
> T: Yes, they move based on sound. Since their sense of hearing is so strong, what do they do? They move based on sound.

In the last lesson observed, David discussed how plants reproduce, where he talked about how new species can be obtained by planting seeds.

> T: Children, reproduction means <increasing, rising>. This is a common characteristic of living creatures. <Reproduction is an event that humans or other living creatures carry out in order to survive >. What happens in the case of no reproduction? Species will disappear over time, and once this happens, we can no longer see them↑. However, what is the common characteristic of living creatures? Reproduction. Humans reproduce, animals reproduce, plants reproduce, birds, fish, they all reproduce. However, there are some differences in the reproduction. Some living creatures reproduce by giving birth and some living creatures reproduce with eggs. ALL RIGHT, HOW DO PLANTS REPRODUCE?
> S7: By planting.
> T: Hmm, what do you plant in soil? We once again plant the seeds we obtain from trees or plants. When we plant them, we generate a new kind of tree or plant.

Carla: Having an enthusiastic personality, Carla is quite kind to her students and expects them to treat her equally as kind in their conversation and behavior.

> T: Let me clear the board at once ((She clears the board and continues to talk in an exciting manner after turning to face them again)). The topic on temperature requires you to recall information from

earlier grade levels, a bit from fifth grade and a bit from seventh grade. Temperature, hmm, is one of the topics which is not included in your textbook. However, there are questions on this subject on your test. I hope that you are solving questions from different publications outside of your textbooks↑.
Ss: Yes.
S9: My teacher, hand me that book.
T: ((She turns her back to the board and faces the student)) YOU MEAN BY HANDING?
S9: Could you please hand me the book?
T: Anyway, here you go↑.

Carla calls her students by their names or uses the word "you" to refer to them. When teaching a new topic or making a definition of a new concept, she clearly expresses the concept and poses many questions about it, like "What comes to your mind about this concept?" She uses the classroom board in an effective way. She waits for students' confirmation of understanding after she makes a definition or explanation.

T: (…) It spreads. Well, how would you come up with a common definition for solids, liquids and gases? (,) Consists of particles:::
S1: Consisting of particles, occupying space, hmmm having a particular volume.
T: If it occupies space, then volume means something which occupies space in the universe. >You don't have to repeat it<. All right, does gas have a mass? ((Students think quietly and start to whisper)) Does gas not have a mass? ↑
Ss: It has mass.
T: For example, let's take cars. Some cars use LPG tubes. You fill the tank up with liters of gas. That's right, isn't it?
Ss: Yes
T: Does the gas consist of particles? Does each particle have mass?
S2: It does.
T: Then, what do we call something that has mass and occupies space in the universe?
Ss: Matter.
T: Matter. Matter consists of particles, right?
Ss: Right.

Carla does not want her students to adhere to standardized patterns. The students were making noise in the class at the time between the end of the break and the teacher's arrival back to the class, and the classroom leader complained to the teacher about the students who were being noisy when the teacher came back. In order to discourage these students from being noisy and talking, the classroom leader wrote the names of those students who were being noisy on the board. However, Carla objected to this system, although other teachers apply it in other lessons.

T: (…) Is it understood? What happens to the temperature of a matter if you remove heat from that matter?
S6: It is going to decrease.
T: It is going to decrease. However, a while ago, our friend said that the sun comes to mind when you speak about heat. There was no sun last week; we could not see it, right? The sun light could not completely reach us because it was behind the clouds. Since it was not able to give heat to us, the temperature, as it is today, was 12 degrees :::
Ss: It was not.
T: It was not. It was below 10 or between 11 and 12 degrees. Now you understand why?↑ In that case, since I have already provided you with the definition of matter (,) I now want to define heat and temperature. We are going to move a bit beyond the topic of heat and temperature; but, I want you to see. ((She moves to the board and just as she is about to start writing…) I WANT TO WARN YOU, DO NOT WRITE THE NAMES OF THOSE WHO TALKED ON THIS BOARD! ((She gets angry)). If you are going to talk, you will do so in any case (hhh). Let us write "heat" here in big font ((She writes on the board)) and here let's write "temperature".

Carla includes national values in her discourse. Even though it is not related to the topic of the lesson, she talks about these issues with her students and assigns homework involving topics outside of the scientific context.

T:Children, actually, these topics are a bit easy for you (.) hmmm, or should I say, they are not that intense for you. We have learned about matter and heat; that is, how matter transmits heat to other matter? We are going to see how heat transmission occurs…Let us see what happens in heat isolation.

> What type of matter are we going to use in heat isolation? ((She moves towards the tables)). Let me fill in the classroom book ((She writes the objectives of the day in the book. She looks at the date)). What day is it today?
> Ss: Monday
> T: What date is it?
> S7: The 12th
> T: Does it have a special meaning?
> S9: Yes. It is the 97th anniversary of the National Anthem ((The student is a bit uncertain))
> T: Is it not The Acceptance of the National Anthem? All right, what is special about March 18? ((Whispers in the classroom, a period of waiting for two minutes)). Yes, tell me↑ so I can learn it from you, maybe I do not know ((Again, she looks in the classroom book and checks the names)) Why is S11 always absent from school? ((She counts the names of everyone one by one and then raises her head from the book)). Yes, tell me what is the importance of March 18? ((Whispers once again start in the classroom))
> S9: Civil defense
> T: That was last week (.) What comes to your mind when I say Çanakkale?
> S3: A place
> T: Yes, Çanakkale is a place. However, what is its importance to us?
> S8: War
> S10: Martyr
> T: Ohh, you have totally forgotten about the issue. ↑
> S11: My teacher, by the way, happy belated International Women's Day.
> T: Altogether @@. Thank you. Yes, when we say Çanakkale, why is it important to us? That is all? ↑ ((She gets angry)) I am giving you some nice homework, but it is outside the scope of our course. It is going to be on the Çanakkale Victory. Okay? = Look at how the war was fought on that front, what happened, how many martyrs do we have? Okay? And I want it tomorrow. That's your homework today. Did everybody write that down? ((She walks around the classroom)).

Eggins (1994) referred to the ratio of the number of words used to the total number of words as "lexical density". Based on this definition, Carla has a high lexical density. She frequently has recourse to saying "Is it correct?, Is it done?, Is it ok?, Is it understood?, Are there any problems?, and Let's do it". Even though she speaks loudly, students sometimes do not understand what Carla is saying. She speaks too fast and frequently repeats her sentences. In order to check if something is understood, she expects the students to complete her sentences.

> T: Okay, wood is short-lived. All right, shall we do it this way? Let us do a couple of examples. Which is a heat conductor, which is a heat insulator? You tell me. Copper coffee pot?
> S9: Well, hmm.
> T: If we say once again well:::↑
> S8: ((He warns his friend)) Say its name completely.
> T: Copper coffee pot?
> Ss: Conductor.
> T: Copper is METAL. Conductor. Styrofoam?

In addition, she tries to encourage her students who feel apprehensive about giving an incorrect answer.

> S1: Insulator.
> T: Insulator. Steel cooker?↑
> S5: Conductor.
> T: Silicon wool?↑
> Ss: Hmm.(There are whispers))
> T: Loudly::: Children I am old, I cannot hear your voice ((Chuckles start in the classroom)) Yes, S8?
> S8: Insulator.
> T: Insulator. Glass?

Carla believes that female and male students have different knowledge structures and is also of the opinion that different occupations attract their attention.

> T: (…) Lignite and coal are said to be obtained by powdering and subsequent application pressure. What do we call liquid fuels? We mentioned gas oil.

Ss: Petrol
T: All right, what if we do not consider it as petrol, but within petrol…
S9: Benzine, diesel fuel.
T: What if we create categories of diesel fuel, benzine, and fuel oil. Gentlemen know that there are some cars that operate with benzine, and some with diesel fuel. Is that correct?↑ What is the difference between them? Gentlemen? For example, tractors mostly use diesel oil. See, we say diesel fuel, diesel, right? ((There is silence in the classroom)) Do you know the difference between them? Gentlemen?↑Have you ever noticed? What is benzine? That is to say, why benzine, why diesel fuel? Why do we say diesel fuel and diesel? (2s) Homework↑ For the entire classroom. You investigate benzine, diesel fuel, and fuel oil, all of which are derivatives of petrol. What is <the difference> between them?
S12: Are we going to investigate all of them?
T: These three (2s). Gas oil is used in gas lamps and gas heaters ((She writes on the board)). Benzine is used in motor vehicles. I am going to write them in the most generalized form ((She points out)) These three for investigation (…) Among you, is there anyone who wants to be an automotive engineer?
S8: What teacher? ((The ones who heard of it for the first time))
T: Automotive engineer (.) Petrol engineer (4s). Machine engineer (2s).All right, new homework ((Chuckles start in the classroom)). You are also going to investigate automotive engineering, mechanical engineering and petrol engineering. Yeah, learn the occupations↑ Teacher, doctor, soldier, these are not the only occupations (…)Gentlemen, or ladies, have you ever heard of these occupations ↑? (…) What you want to be, your dreams, should appear in your minds. For example, S1 ((She points out the student)) can be a great automotive engineer.

Finally, Carla includes socioscientific-based discussions in her lessons to ensure that the students have a solid grasp of the topic. In relating these discussions to the topic of fuels, she mentions the importance of dams to the country, the use of natural fuels, and the consumption of water sources. She initiates a discussion based on the basic energy sources.

T: (…) The answer is natural gas. Among these fuel types, natural gas is the one which damages the environment the least. All right, where do we get the natural gas from? (.) ((No response from the students)) Haven't you watched the news? Let me ask from which country do we get it?
S12: Russia
T: We get it from Russia. This has become general knowledge. Children, in terms of natural gas ↑well, we have mentioned the chemistry industry↑ we are de-pen-dent on Russia. On this topic, is it understood? And, people opt to use natural gas in newly constructed places, new dwelling units. One of the reasons, maybe the biggest one, is that among the other fuel types, natural gas minimizes environmental pollution. All right, I will ask another question (7s). We are 1-2-3-4-15 people here. You all are the energy minister of this country. Your country gets so polluted that there is no clean air (.) anymore. Did you watch the movie Wall-E? A robot that is on its own in the world.
S9-S2: I did watch it. It was rather beautiful.
Ss: I have not heard of it.
S9: Wall-E?? What?
T: I am saying this for the ones who have not watched it yet. Wall-E is all alone in the world. There is not a single living creature. Wall-E is a robot. There is no single source of oxygen. The air is completely polluted. Carbon dioxide etc., and, the reason Wall-E can survive is that it does not breathe because it is a robot. Imagine that we are going to such a country, a world. And you are the person who is responsible for the energy in this world (3s). In order to minimize this air pollution in the world, you need to take precautions, particularly in terms of energy. Which types of energy would you use?

The Primary School Teacher and Science Teachers' Discourse toward Students

Discourse in Gender Issue

In this study, where critical analysis of the discourse of two teachers was carried out, the issue of gender had an effective impact onto the discourse. Hanrahan (2005) highlighted that an interaction exists between the gender of the teacher, the student and the researcher, and that these issues should be dealt with separately. To account for this interaction, one female teacher and one male teacher were intentionally selected for this study on concept teaching in science classrooms. The teachers selected participated in the study on a voluntary basis, and both teachers met with the author of this study prior to its start. It was important that the teachers had been working at their respective schools for a certain duration of time, and particular attention was paid to this situation because text analysis involves some limitations, as indicated by Fairclough (2003, p. 15), who defined these limitations as “involvement of texts in meaning-making, the causal effects of texts, and the specific ideological effects of texts.” In order to overcome this limitation of studies, he proposed the analysis be performed within an ethnographic framework. With this purpose in mind, the study was based on the culture of the institution studied. However, Carla had started her new position at a different school (the school where this study was carried out), and therefore frequent visits were made to this school by the researcher, who attended one lesson per week, each in a different classroom, free of charge. The purpose behind this was to get familiar with the culture of Carla’s school and to minimize the limitations associated with CDA. Both teachers were aware that the observation and interview records obtained from them were going to serve scientific purposes. Another reason Carla was included in this study was the low number of female teachers in the available sample population. There were not many female science teachers in the region where the researcher was located, and most of the teachers who were volunteers were teaching for particular hours in lessons at a particular fee (Turkey makes use of substitute teachers). This situation threatened the ability to observe their lessons, considering that their continuity in lessons was not always possible and they could be assigned to a different school.

The fact that David was a male teacher had no impact on the mixed gender structure of the classroom. That is to say, David tried to treat the male and female students in his classroom equally. However, in some cases, David did seem to have a bias in favor of male students, particularly in his in-class applications or in his tactile warning to students (he would touch them on the shoulder), where he would choose the male students. David did not make a distinction between his female and male students in his discourse but did so in his behaviors. In the interview, David expressed that he behaves in this way in order to prevent misunderstandings. On the other hand, there was no difference in the female and male students’ approach to David. In his discourse, David used more sarcasm towards his male students, which can be attributed to David’s patriarchal understanding. He was aware that his female students could possibly get offended by his sarcastic behaviors, as his students were rather shy. While David would call male students “mate” or “my man”, which are cultural expressions, he would call the female students “lady”. In short, David used different discourse for male and female students.

Carla has a teacher profile that is energetic and active, but she is not firm in her teaching approach and talks fast. Her personal teaching style contributed to her communication with her female students, as she did not allow them to talk with each other and was able to successfully keep their attention focused on the lesson. In her classroom, the female students, under the motivating discourse used by Carla, were willing to talk more. However, Carla, like David, included gender discrimination in her discourse, particularly when it came to talking about occupations. She stated that industries like the machine and automotive are more suitable for male students. Yet, in doing this, she was actually attempting to engage the attention of her male students, who seemed less attentive in the lesson. In other examples though, she included images of femininity and motherhood. For instance, at one time, she presented an example of pudding that mothers cook, and in the heat isolation topic, she said that men sometimes were lightly clad in cold weather. Carla’s classroom was more dynamic than David’s and not boring. However, Carla would sometimes get frustrated, as she expected more from her students, and the motivating sentences she used to encourage the students led to the sense of shyness and chuckles among the female students, which gave the impression that Carla was more interested in attracting only the female students’ attention. However, this tendency cannot be regarded independent of the sociocultural context, as female students in the Turkish society always feel closer to female teachers. As a researcher, it is important to point out that the discourse of both teachers, including their gender-related discourse, was presented in an objective manner, along with their justifications. These justifications were obtained based on the teachers’ approach to their students and the behaviors observed among their students.

Discourse in Authority and Power Issue

In David’s classroom, the teacher was the main source of authority and decided on the activities to be carried out in the classroom, the topics to be completed and how to proceed with and shape the curriculum. David controlled the questions posted, and his students made explanations consisting of only a couple of sentences; in other words, an atmosphere of discussion was not formed at all. The ideas were not questioned, and only temporary answers were provided for the questions the students were curious about. This strict approach to teaching science is a barrier to building enterprising skills in the students and having them take initiatives. The students, as a result of this type of concept teaching, believed that science should not be questioned and that it can be learned through the knowledge transmitted by the teacher. Science taught in this way was limited to what the teacher said and the knowledge presented in the textbook. A single explanation regarding any given concept was given, and ready-to-use knowledge was presented to the students, as the teacher provided the definitions of scientific concepts. The impression received from the class observation of David is that his students avoid questioning authority for fear of being the laughing stock of the classroom; based on this, the teacher did not put that much effort into actually teaching. These observations were strongly related to the wording norms stated in the book by Lemke (1990) and indicated the powerful position of the teacher in the classroom. The main indicator of this position is the central place David holds as the expert of the classroom. To nurture a love of science in the students, David did little more than have his students watch videos; he did not use laboratory practices, did not question the argument structure of his students and stationed himself as the center of power in the classroom by adopting a teacher-centered approach.

Carla's case was different. She, rather than being the authority and center of power in the classroom, adopted the role of moderator in the classroom. She put forth efforts to encourage her students to engage in discussion and sought to identify their argument structures. She recommended extracurricular activities and applications. She did not include laboratory practices in the classroom, but this could be attributed to the inadequate facilities her school provides. Carla did not present the meaning of the concepts to her students; on the contrary, they constructed the meaning of the concepts together. She discouraged her students from forming incomplete sentences and attempted to relate science to the students' daily lives. Furthermore, she attempted to tacitly or directly encourage her students and did not shy away from being laughed at; rather, the teacher discourse was entertaining to the students and served to arouse discussion among the students. Nevertheless, Carla did not participate in the students' conversation related to extracurricular topics, as this was her way of protecting her dominance over the classroom. Rather than positioning herself as an expert in the classroom, she guided her students to facilitate their self-learning. She was able to successfully make learning more attractive by applying sociocultural examples. All in all, Carla's discourse was appreciative and supportive.

Discussion

A critical analysis of two teachers' use of discourse during concept teaching in elementary school and middle school science courses in Turkey was carried out in this study. According to the CDA performed, there were some distinct differences between the discourse used by the two teachers. These differences could have resulted from the teaching level or the gender of the teacher, either of which can be regarded as a reflection of the ideological perspectives the teacher possesses. The differences in the discourse used by the teachers were reflected on the behaviors of the students in their classrooms, limited the in-class student-teacher interactions, were effective on the classroom's center of power, and were determinative in nurturing a love of science in the students. That is to say, the teachers' discourse played a decisive role in the students' learning of science. In the study, the discourse of the male participant, who teaches at the elementary school level, indicated that certain cultural influences had an effect on his discourse, considering that he used discourse pertaining to his culture and used the patriarchal language inherent in the patriarchal society. Delpit (1995) and Calabrese, Barton, and Yang (2000) highlighted the cultural power of science and the cultural power of language, stressing the power of the language teachers use, how this power is obtained, and how the power culture of science is formed. In order to realize strong, effective science teaching, it is important that teachers improve their discourse and understand how this power culture has been formed. Moore (2008) argued that teachers are responsible for facilitating their students' use of scientific language and their understanding of this language, stressing that teachers who intend to establish the connection between scientific language and daily language need to advance this responsibility further. Calabrese, Barton, and Yang (2000) put forward that teachers must carefully construct their understanding of science, language, and authority in order for students to be successful in science learning. The female participant, Carla, who teaches at the middle school level, used powerful language to distinguish between the occupational preferences of her female and male students. Both of the participants' discourse point to a social reality, one that is reflected in their discourse at the expense of attracting students' attention. However, the patriarchal discourse of the female participant was not as disturbing as the one used by the male participant, considering that the former's use of it did not necessarily infer that she ideologically holds this perspective, but rather, that she had recourse to it to attract the students' attention and get them to engage in discussion. At this point, it is important to consider the differences in the curriculum at the different teaching levels. In this matter, the CDA can be used to compare the access to science that students who are taught by different teachers have. In fact, through the observations of the lesson, it was revealed that Carla experienced difficulties in completing the curriculum applied, and that she felt her students needed to know everything and take a test-oriented approach to study in order to prepare for the state-administered exams. To summarize, as part of the CDA, the teachers underwent long-term observation by the researcher, and the analyses were conducted over a sufficient time period for the purpose of presenting future policy recommendations. The results of these analyses showed that different applications for concept teaching in science lead to different styles of learning. At the level of elementary school, the concepts were presented in a clear and ready-to-use manner but the more entertaining and inquiry-based features of science were ignored. At the level of middle school, on the other hand, the explanations regarding the concepts were constructed together with the students, and scientific inquiries were carried out. However, the intense curriculum of science at this level put pressure on the teacher, which, coupled with the disadvantageous conditions, turned the science teaching process into preparation for the exam.

Conclusion and Implications

This study investigated the discourse of two teachers in Turkey using CDA and attempted to reveal how concept teaching is performed in the science classroom, how student motivation is achieved, and how the student-teacher interactions take place. The analyses made indicated that teachers' discourse in the mid-21st century in Turkey is still shaped by power dynamics. Concept teaching at the elementary school level is performed through explanations provided by the teacher, who is positioned as the center of power. This approach regards science as being unquestioned with strict boundaries filled with absolute facts. At the middle-school level, science is open to inquiry and discussion and is innovative, and entertaining. However, the disadvantages of the schools (for example, the negative discourse of other teachers) and the intense curriculum are reflected in the teachers' discourse, which prevents students from allocating more time for science and taking initiatives. However, it is the disadvantaged students in the classroom who are most negatively influenced by this situation. Yet, it is a situation that can be resolved with a change in discourse. The adoption of an intellectual perspective could also change students' perspective towards science. A stronger willingness to learn science can be effective on students' achievement in science and their intrinsic motivation. Clarifying science concept teaching by constructing definitions with students, adopting a terminological perspective, investigating argument structures in the classroom, and relating concepts to daily life can assist in creating active student participation in the classroom. The updating of the educational policies in the country is certainly going to have an impact on the direction of teacher discourse. Moreover, the exam-based educational system in Turkey leads to traditional test solving rather than to experimental approaches and focuses on knowing single correct answers, which results in no classroom discussions or recognition of the value of learning from making mistakes. This situation puts pressure on the teacher to quantitatively increase the number of students who are successful in the exam. The case in elementary schools, on the other hand, is quite different. Pedagogical requirements are needed to soften the discourse of elementary school teachers, an issue that educational policymakers should take into consideration. As a result, CDA is often used in studies that take into account social issues such as politics, ideology or racism (Sugrue, 2019; Wright & Brookes, 2019). In the studies conducted in the field of education, it is determined that the discourses in the textbooks or other educational materials are generally examined (Babaii & Sheikhi, 2018; Lindgren, Hildingh & Linnér, 2017). At this point, it is possible to say that the present study is strong in terms of examining the teacher discourse in the classroom environment, but it also has a certain limitation in terms of giving a limited number of teacher discourse structures in the same study.

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The Effects of 5E Model Supported by Life Based Contexts on the Conceptual Understanding Levels Measured Through Different Techniques

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Abstract

In this study, it was aimed to determine the effects of the learning process based on the 5E Model Supported by Real Life Based Context in the Unit of Force and Energy in the course of Science on the conceptual understanding levels of the students at the seventh grade which are measured various techniques. The research was designed with quasi-experimental design with pre-test post-test control group and the lessons were taught in the experimental groups through lesson plans developed according to 5E Model Supported by Life Based Contexts while, in the control groups, the lessons were conducted through methods based on transmitting or presenting information. The study group of the research consists of 80 students who study at the level of the seventh grade. The conceptual understanding levels of the students were measured through the Life-Based Concept Test and Concept Maps. The data of the research was analyzed via MANOVA statistical method. The students in the experimental group were seen to have higher average statistically significant scores in both Life-Based Concept Test and Force and Energy Concept Maps when compared to the students in the control group. In the research, it was observed through tests in various formats that the teaching process conducted based on real life contexts through integrating the Life Based Approach into 5E Model was effective on the development of conceptual understanding levels of the students in the unit of Force and Energy.

Introduction

As a pedagogue, Helen Keller defined a well-educated person as the one who understands the life s/he lives in the best (Gültekin, 2007). From this perspective, it can be stated that education is valuable so long it enables the interpretation of life and plays a functional role after integrating with life. Starting from that window related to the function of education, Science education is one of the fields of education which is integrated with life and holds the process of life. In today's world where the role and force of science is undeniable fact in the economic development and improvement of the countries in terms of producing societies, the value which individuals attribute to science continuously gains significance. For that reason, there is a need for a perception which regards science as an instrument in interpreting life and solving the problems encountered in life. In order to fill the gap between the Education of Science and real life, various projects and application of teaching programs where "the contexts of real world" were commonly used in the UK in 1980's and many other countries afterwards were initiated. The Context Based Learning Approach which are called context based approach or contextual approach (Barker and Millar, 1999; Bennett and Lubben, 2006; Gilbert, 2006; Holman and Pilling, 2004; Whitelegg and Parry, 1999) and based on social constructivism and situated cognition (Berns and Erickson, 2001; Crawford, 2001; İlhan, 2010; Nentwing et al., 2007; Taasoobshirazi and Carr, 2008) is a teaching-learning approach which is based on the formation of the learning process where teaching is conducted on the base of need to know (Bulte, Westbroek, De Jong and Pilot, 2006) and includes daily life occasions that are familiar to the students.

Teaching of Science based on Life-based Contexts

Its heavy content and information overload to the students is an important criticism for teaching programs for the course of science in the researchers conducted on the education of scientific courses (Gilbert, 2006; Pilot and Bulte, 2006a). Another criticism is that the students fail in associating the information they learn during scientific courses with daily life and interpret it (Gilbert, 2006; King, 2009; Konur and Ayas, 2010; Stolk, Bulte, de Jong and Pilot, 2009). As a natural result of those problems, the students encounter problems in adapting to the scientific courses and being motivated (King, 2009). Moreover, Gilbert (2006) accepts the isolated status of the concepts in teaching programs of scientific courses from real life as one of the major problems encountered in science education. The employment of real life-based contexts in teaching and measuring scientific subjects was relocated to the central office by the Program for International Student Assessment (PISA) conducted by the Organization for Economic Cooperation and Development (OECD) in order to evaluate the scientific literacy among the students (Fensham, 2009). When science teaching programs of the countries which display high success in PISA exams that aim to measure the scientific literacy in general terms and the skills of the students in applying the information they obtain at school in their daily life, it is striking that the contexts related to daily life were employed in teaching scientific concepts. Real Life Context Based Learning Approach is based on choosing an event, occasion, a living creature or a thing which are familiar to the students as a context and learning process is initiated with this context and formed around this context. Thus, the student is enabled to learn scientific concepts through associating with context.

Gilbert (2006) stated that the education model which materializes the meaning of context should be able to present an effective answer to the related curriculum and social problems. From this point of view, it can be stated that a context chosen from real life is a basic and organizational structure which constitutes the core of life based learning approach and skeleton of life based learning process. The teaching begins with a context where the student is familiar from his/her socio-cultural environment, the concepts are taught within this chosen context, the taught concepts are associated with other contexts and thus the effectiveness of learning process is increased. Within this period, the context and learning shape each other. From this point of view, in this research Life Based Learning Approach was adopted in Energy which is an interdisciplinary issue and Force which constitutes a base for numerous issues in Physics (Weight, Gravitational Force, Pressure etc.). Real-Life Context Based Learning Approach is a new application for the level of secondary school level although it has been applied at the level of high school (King and Henderson, 2018). Within this scope, it is thought that the research is significant for observation of the applicability at secondary school level through the contexts of real life within the scope of teaching scientific concepts and their effects and the application of Life Based Learning Approach at secondary school level.

Conceptual Understanding and Concept Teaching in Science Education

In the book “what do you care what other people think”, Feynman (1988) narrates the effect of his father on his way of perceiving the world and emphasizes that his father narrates everything he reads after he interprets the actual meaning of the things he narrates. For example, he states that his father narrates a dinosaur which is 8 meters tall and the width of its head is 2 meters they read in an encyclopedia saying that “if it were in our front yard, it would be tall enough to enter its head from our window but it would break the window since its head was big”. Through this instructional attitude which Feynman’s father displayed, Feynman translated everything he reads into reality, he re-interpreted them according to his own perception and conceived it. This example emphasizes the importance of making meaningful the effect of learning on conceptual dimension by integrating science with life. Starting from this perspective, the researches in the dimension of conceptual understanding indicate that the students developed beliefs and ideas about some concepts and events without receiving any scientific education and brought along those beliefs into class (Amir and Tamir, 1994, Driver, 1983; Treagust, 1988; Osborne and Wittrock, 1983). Novak called those beliefs and ideas “pre-concepts” while Driver and Easley employed the term of “alternative concepts” (Yağbasan and Gülçiçek, 2003). Yakışan, Selvi and Yürük (2007, p.60-61) defined the alternative concept as the mental model and definitions different from scientifically accepted opinions and in relation with the other elements in mind not incorrect answer which are randomly given in order to explain a situation. As Tregaust and Duit (2008) also state, those incorrect concepts which are structured in minds except its scientific meaning mostly display a strong resistance against changing. For that reason, teaching concepts and, thus, understanding at conceptual level is rather significant in preventing the formation of alternative concepts and sorting out the existing ones in the course of science which also numerous abstract concepts. Because, establishing new information at conceptual level correctly requires the construction of new information on the previous ones. The construction of information begins at very young age and is established on the experiences and comments which a child acquires in daily occasions. Development of a complete understanding takes place in time and occurs as a result of repeated contacts with concepts (Wild, Hilson and Hobson, 2013).

The conceptual understanding can be defined as deep learning where the relationships and similarities between concepts are clearly defined, those concepts are transferred into new environments where necessary and they could be used in solving the problems encountered in daily life (Sinan, 2007). Imbuing the culture of science which is needed at every stage of life to the students healthily is directly proportional to the effectiveness of teaching concepts through the courses of science (Yağbasan and Gülçiçek, 2003). When the fact that majority of the students had difficulty in understanding scientific concepts (Gobert and Clement, 1999) is considered and scientific concepts are discretely narrated from daily life in addition to their abstract structure, this occasion may cause the failure of students in associating the scientific concepts with events and phenomenon from daily life and formation of a false mental structure related to that concepts. The main idea of science education based on the contexts of real life more clearly defines both concepts where the concepts are employed and the relationships between those contexts and concepts (Gilbert, Bulte and Pilot, 2011). Starting from her research, King (2009) stated that the relationships between concepts and contexts could be developed through life-based learning. Through the emphasis that the issues and concepts of science could be meaningful on condition that they are functionalized and starting from the importance of establishing connections between concepts and daily life contexts in learning, the Learning Approach Based on Real Life Contexts and 5E Method were preferred in the organization of this approach. The 5E Method provides learning a new concept and trying to understand a concept which is known in every detail (Ergin, Kanlı and Tan, 2007). Bybee (2014) explains the effectiveness of 5E Method in teaching concepts and conceptual understanding as follows;

> at the stage of Engage, teacher or curriculum help students engaging a new concept through employing short activities which arise curiosity and reveal preliminary information. The importance of this stage is that it provides opportunities to the teachers informally determine the misconcepts articulated by the students. The Stage of Exploration provides the students a common base of activities where current concepts (misconcepts etc.), processes and skills are defined and conceptual transformation is facilitated. The Stage of Explanation focuses the attention of the students into a definite point of their experiences at the stage of curiosity and exploration and gives them the opportunity of showing their conceptual perception. An explanation coming from the teacher or another resource can direct the students towards a deeper perception and it is a critical characteristic of this stage. During the Elaborate Stage, the students develop a deeper and broader perception through new experiences. The students apply the concepts and their skills which they acquire through additional activities into new occasions. The Evaluation Stage encourages the students to understand their own understanding and evaluate their skills.

According to Bybee (2014), the 5E Method is based on learning psychology and the observation that the students need time and opportunity to formulate and restructure the concepts and skills. On the other hand, it was observed that there is a limited number of researches on the fields of Science about use of contexts in Life/Context Based Learning and how to conduct the teaching process. As a matter of fact, Ültay and Ültay (2014) determined in their study where they conducted content analysis of the studies in the literature related to Context Based Physics Studies that there is need for suggesting a model for context-based approach to the teachers and researchers that teachers can apply for the context-based teaching starting from their determinations it isn't a pedagogic model to show the steps the teachers apply for context based teaching. Starting from the emphasize of Finkelstein (2001) within this framework that the students structurize the information within a context and the context is an instrument in interpreting the information and context based approach is a supplementary element of context based approach in this study (Tekbıyık, 2010), the 5E Method is thought to integrate the function of context throughout its stages, and it was preferred as a base in conducting life based teaching applications and teaching scientific concepts.

Evaluation of Conceptual Understanding

In classrooms which consists the core of teaching, it is important to structure the programs of science so that they enable students' conduct conceptual understanding. However, another supplementary element of structuring a teaching process so that it enables conceptual understanding is the designing of evaluation activities in accordance with teaching methods (Black and William, 1998; Kavanagh and Sneider, 2007; Yin, Tomita and Shavelson, 2013). When the literature is reviewed, there are striking studies where Life/Context Based Learning Approach is adapted and are about the students' learning concepts, sorting out the misconcepts or the development of conceptual success (Akbulut, 2013; Bennet and Lubben, 2006; Çekiç Toroslu, 2011; Demircioğlu, 2008; Finkelstein, 2005; King, Bellocchi and Ritchie 2007; King, 2012; Kistak, 2014; Nentwig et al., 2007; Peşman, 2012; Tekbıyık, 2010; Özkan, 2013). According to Ekinci (2010), the results which life/context based approaches present are positive in terms of the effective development perspective while conceptual development isn't satisfying. It results from some deficiencies in the construction of the researches, their methods or applications. Tokiz (2013) determines that the evaluation of conceptual understanding among the students has gained importance in understanding whether an effective learning occurs. Accordingly, the Life Based Concept Test and Conceptual Maps were preferred in this study for using together in the evaluation of the conceptual understanding in the unit of Force and Energy in the education through 5E Model supported by Life Based Contexts.

It was aimed with Life Based Concept Test to determine the levels which students are able to transfer the daily life concepts and combine the contexts they learn within those concepts and contexts. The Concept Maps were used to understand explore the meaning which students attribute and how they establish relationships between the concepts with different importance, the concepts and the examples of concepts (Kaya, 2003).Within the scope of the research, an attention was paid so that the concept test which was developed for the determination of conceptual understanding would be in a life based form. When the tests of science questions in the PISA exams are analyzed, the existence of a life based measuring perception can be observed. In their research which they conducted through two different tests consisting of life based and traditional problems, Tekbıyık and Akdeniz (2008) determined that the students found the life-based problems more understandable, more concretizable and more attracting when compared to the classical or traditional problems. Bulunuz and Bulunuz (2013) regarded the students' encountering difficulty in solving a problem from real life as the indication of the failure of the operative (algorithmic) problem solving technique and, for that reason, it is necessary to focus on the solution of problems in relation with real life and based on conceptual understanding and reasoning instead of operative problem solving applications in teaching science.

On the other hand, Kaya (2003) states that concept maps present detailed information to the teachers in understanding the employment of concept maps as an instrument of measuring and evaluation, how they establish relationships between the concepts with different importance, and the concepts and the examples of concepts. Since understanding how students structure information in their minds and how they learned concepts is a difficult and complicated process, it is suggested to employ different methods with specific advantages and disadvantages (Tokiz, 2013). Researchers emphasize that concept maps are a meta-cognitive tool, that concept mapping improves higher-order thinking skills and can therefore be used as a powerful assessment tool (Cañas, Novak, González, 2006; Novak, 1990; Novak and Cañas, 2006). From this point of view, it can be stated that the evaluations conducted through concept maps is an effective technique among the students in terms of establishing between the concepts and expressing those relationships and observing their high levels thinking abilities. Cañas, Novak and González (2006) point out that there is a good theoretical infrastructure and empirical reasons which provide motive for the more commonly employment of the concept maps. The researches indicate that concept maps are more effective in revealing the conceptual information structures of the students when compared to the standard test (Markham, Mintzes and Jones, 1994; Ruiz-Primo and Slavelson, 1996; Taber, 2002).As a matter of fact, McClure et al., (1999) states that standard tests largely limit the students about the answers they will give and fail in providing enough information about the structure of conceptual information.

It can be stated that employing the measurement instruments which conform to both nature of the method (Bennett, Lubben and Hogarth, 2007) and the structure required by the information/skills targeted to observe (Sinan, 2007) would be better instead of evaluating the data obtained from a single test in the interpretation of the development of conceptual understanding through a Life/Context Based Learning Perception. In accordance with all the things told about the evaluation of the conceptual understanding levels, two different measuring techniques were used in the research which were thought to be the most convenient in the measurement of conceptual understanding in order to avoid the insufficiency of monotype tests and developing measurement instruments which conform to the nature of teaching method considering the occasions where every sort of information can't be measured through every sort of measuring technique and measurements techniques provide advantages and disadvantages.

Method

Research Goal

In this research, it was aimed to determine the effects of the teaching process designed in the 5E Model Supported by Life Based Contexts in the unit of Force and Energy in the course of Science on the conceptual understanding levels of the 7.th grade students. Within the scope of the research, the Conceptual Understanding Levels of the students were determined through Life Based Concept Test and Concept Maps. In accordance with this general purpose, answers were sought for the following sub-problems;

Is there a significant difference between the experimental group which learns through the lesson plans prepared in accordance with the 5E Model Supported by Life Based Contexts in the unit of Force and Energy and the control group which learns through the methods based on transferring and presenting the information in terms of their conceptual understanding levels?

a. Is there a significant difference between experimental and control groups in terms of the scores obtained from Life Based Concept Test?
b. Is there a significant difference between experimental and control groups in terms of the scores obtained from Force and Energy Concept Maps?

Research design

The research was designed in the quasi-experimental design with pre-test, post-test control group. The experimental designs aim to determine the cause and effect relations between the variants (Büyüköztürk, 2001). Two (2) experimental groups and two (2) control groups were randomly selected from five (5) branches in the 7.th grade in a state school in Ankara. In the research which lasted seven weeks, the lessons were conducted according to 5E Model Supported by Life Based Contexts in the unit of "Force and Energy" in experimental groups while the lessons were executed according to the methods based on transferring and presenting information. The experimental design of the research was given in table 1.

Table 1. The experimental design of the research

Groups	Data Collection Instruments which are Applied as Pre-test	Process	Data Collection Instruments which are Applied as Post-test
Experimental Group	Life Based Concept Test Force Concept Map Energy Concept Map	5E Model Supported by Life Based Contexts	Life Based Concept Test Force Concept Map Energy Concept Map
Control Group	Life Based Concept Test Force Concept Map Energy Concept Map	The Presentation Method from the Course Book according to Teaching Curriculum	Life Based Concept Test Force Concept Map Energy Concept Map

Research group

The study group of this research consists of 80 students at the 7.th grade of a state school in Ankara. Four classes were randomly selected from five classes at the 7.th grade so that there are two experimental groups and two control groups and the lessons were conducted by the researcher. In the experimental groups, there are 41 students while control groups consist of 39 students. The information about the experimental and control groups was given in table 2.

Table 2.The students in the study group

Group	Branch	Number of the Students		
		Female	Male	Total
Experimental Group	7E	11	9	20
	7B	8	13	21
Control Group	7A	11	9	20
	7D	7	12	19
Total		37	43	80

Data collection tools

The measurement tools used to obtain the data of the study are listed below:

Life Based Concept Test

In the research, a multiple-choice concept test was developed in order to determine the understanding levels among the students related to the basic concepts in the unit of Force and Energy. The test consisted of taken from the literature (Avcı, Kara and Karaca, 2012; Çekiç Toroslu, 2011; Şahin and Çepni, 2011) and prepared by the researchers. The clauses in the test were established within the framework of life based approach which daily life contexts were employed. Following the analysis for validity and reliability and clause analysis conducted after the pilot application the test was finalized. The test consisting of 25 multiple choice questions which their content validity is provided so that there are at least two questions for each acquisition in the unit of Force and Energy for the 7.th grades in the Teaching Programs of Science has four-option questions. The highest score in the test is 25 while the lowest score is zero. The duration for the application of the test is one period of course (40 minutes). The Cronbach Alpha reliability coefficient of the Life Based Concept test was calculated as 0.81. Within this context, it was aimed to employ the test in order to determine the conceptual understanding levels among the students and being able to transfer the contexts employed in the lessons into the other contexts encountered in daily life (the contexts employed in the test).

The Force and Energy Concept Maps

In order to reveal the conceptual understanding levels of the students related to the issues of Force and Energy and determine the difference between the information structures of the students better (Ruiz-Primo, Schultz and Shavelson, 2001),the concept maps were also employed as another instrument of measurement in addition to Life Based Concept Test. The technique of establishing a concept map starting from scratch in the research. In establishing concept map, the students were given concepts related to the issue and they were asked to draw a concept map through using those concepts. This method has lower levels of directing when compared to the methods of Ruiz-Primo (2004) in establishing concept maps.

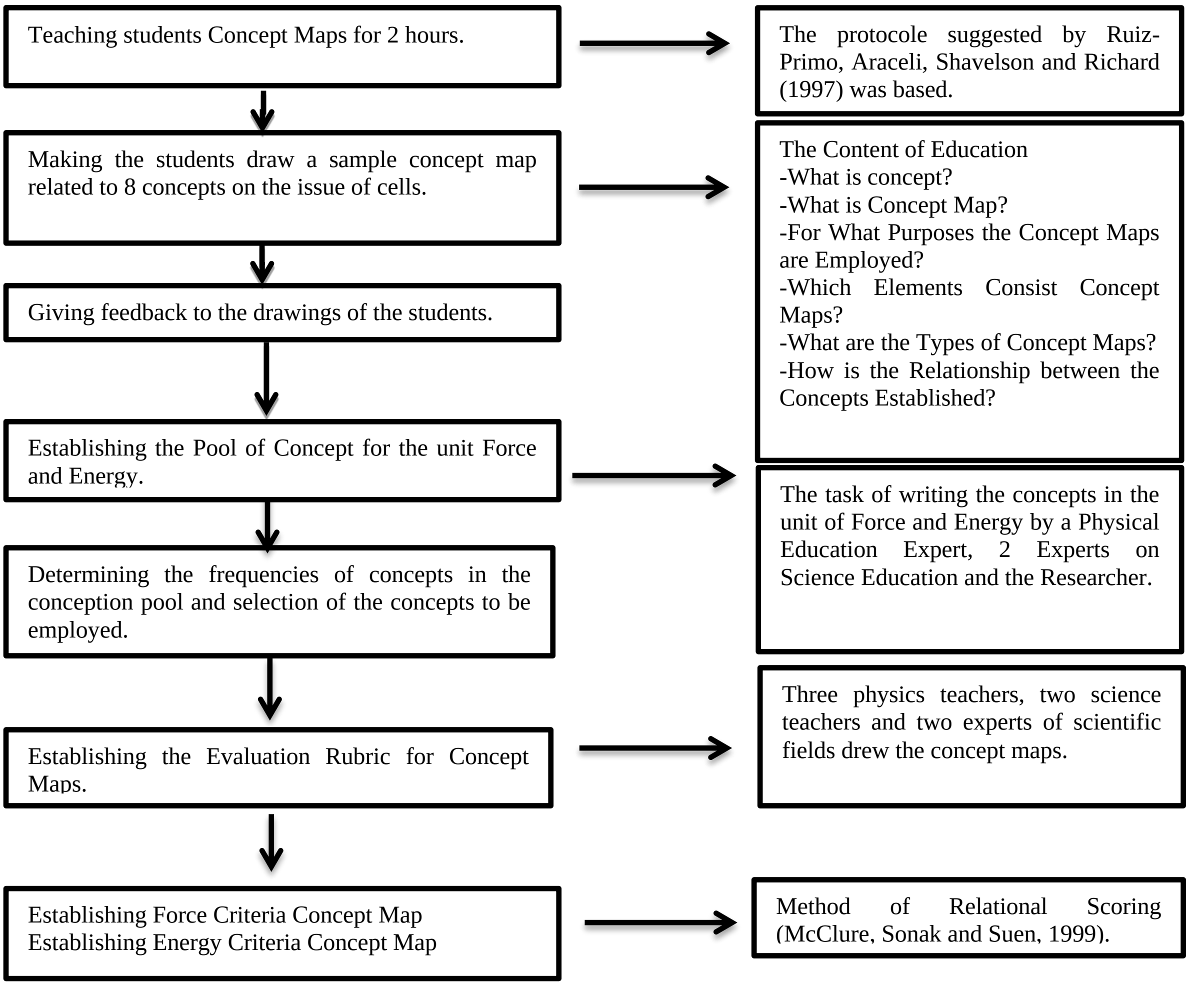

Figure 1. The flow pursued in the development process of concept maps

In addition, two different concept maps called "Force Concept Map" and "Energy Concept Map" within the context of the research since there are numerous basic concepts in the unit of Force and Energy. The reason for following this path is that the application implanted at the level of 7.th grade would be more convenient to the age level of the students. Nevertheless, "a network-type design" was preferred since it contains more than one stages, reflects complicated interactions at various conceptual levels and, thus, displays a high level integrity (Kinchin, Hay and Adams, cited by Taşar et al., 2002). The processes related to the preparation and application of the network-type concept maps within the framework of this research which was preferred as a measurement technique was given in figure 1.

In accordance with the process which was expressed in figure 1, 12 concepts related to "Force" and 13 concepts related to "Energy" were determined. Those concepts are given in the units of "Force" at the 7.th grade and they are "Mass, Weight, Force, Newton, Dynamometer, Pressure, Solid Pressure, Surface Area, Liquid Pressure, Gas Pressure, Gravitational Force, and Force of Gravity". Related to "Energy", the concepts of "Energy, Work, Force, Height to Ground, Kinetic Energy, Potential Energy, Gravitational Potential Energy, Flexibility Potential Energy, Weight, Mass, Velocity, Flexible Object, and Frictional Force". The students were asked to establish a concept map both at the beginning and at the end of the application process. In order to score the obtained concept maps, the criteria-mapped relational mapping method was employed. The relational scoring method was adapted from a technique developed by McClure and Bell (1990) (McClure, Sonak and Suen, 1999). In this technique, each couple of criteria which the student employs in the map are evaluated on condition that they take place in the map. The couples of concepts and propositions which define the relationships between the concepts are scored through the rubric adapted from the study of McClure, Sonak and Suen (1999) between zero and three points. The total of the scores obtained from the relationship between each concept in the map and the total score of the student is obtained. Although there is no an upper limit for the scores to be obtained from the concept maps, maximum 135 points may be obtained according to the criteria concept map. The students were given a period of lesson (40 minutes) for each (Force and Energy) so that they can establish concept maps.

The Reliability and Validity of the Concept Maps

McClure et al., (1999) point out that there may be three sources of mistake which may influence the reliability when concept maps are used as an instrument for measuring. They can be listed as the difference of experiences which students have in establishing concept maps, the differences between the field information of the evaluators and the differences between the scoring of the evaluators. From this point of view, the students were primarily given two hours of lesson about establishing a concept map in order to minimize the error variances in the research which may result from the error sources and the concept maps were established through the concepts on definite issues under the guidance of the teacher, the stages where the students encounter difficulty were observed and activities were conducted to sort out those problems. Another issue in providing reliability is the assessment of evaluators in terms of their field information. The evaluators in this research are Field Experts in the course of Science. Another error source which McClure (1999) points out is the differences between the scoring of the evaluators. In providing reliability which can be defined as the consistency of the scores obtained from the concept maps, generally the consistency between the evaluators is considered (Ruiz-Primo and Shavelson, 1996; Ruiz-Primo et al., 1997). In order to provide the reliability of the evaluators in the assessment of the force and energy concept maps in the research, the scores of the students were scored by two evaluators in relation with the relational scoring protocole according to criteria concept maps and its scoring reliability was tested.

The validity of a measurement can be obtained through providing evidences for content validity, criterion-related validity, and construct validity (Tekin, 2012). Ruiz-Primo and Shavelson (1996) specified that the content validity in concept maps can be obtained through the convenience of the concepts to be employed in establishing the concept maps and containment of the concepts with the structure related to the whole issues. Within this framework, a concept pool was established by the field experts in order to provide the content validity in the concept maps and the concepts were selected from this pool according to their frequencies.

The type of other validity which is analyzed for the validity of the measurement through concept maps is the validity based on a criterion. The criterion-based validity for the concept map is obtained through analyzing the correlation of the scores of the criterion-based validity concept maps and the scores obtained from another instrument of measurement which was proven for its validity and reliability (Ruiz-Primo and Shavelson, 1996; Ruiz-Primo et al., 1997). It is possible to find numerous researches in literature which determine the criterion-based validity of concept maps according to the correlation with standard tests (Conradty and Bogner, 2012; İngeç, 2009; İngeç, 2008; Eroğlu and Kelecioğlu, 2011; Hollenbeck, Twyman and Tindal, 2006; Liu and Hinchey, 1996; Novak, Gowin and Johansen, 1983; Rye and Rubba, 2002; Turan Oluk, 2016; Ünlü, İngeç and Taşar, 2006). The Pearson Correlation coefficients between the total scores obtained from the concept maps in the research and Life Based Concept Test and it was found 0.89. There is a positive, high and significant relationship between the total scores of concept maps and Life Based Concept Tests.

Structuring and Application of Teaching Method

It is of importance to choose the teaching method in which the context to be employed in teaching supported by the life-based contexts being able to realize its function properly. Because, the method to be employed needs to provide a ground that can provide the mobility of the context and coordination of the education process. Infact, the technique that will be employed within this framework should be in the structure which can lead to life based teaching. In the development of lesson plans which real life based contexts will be employed, the emphasizing of "Contextual Structuring" which Finkelstein (2001) stated that the students structured information within a context and the context is an instrument in interpreting the information was based on.

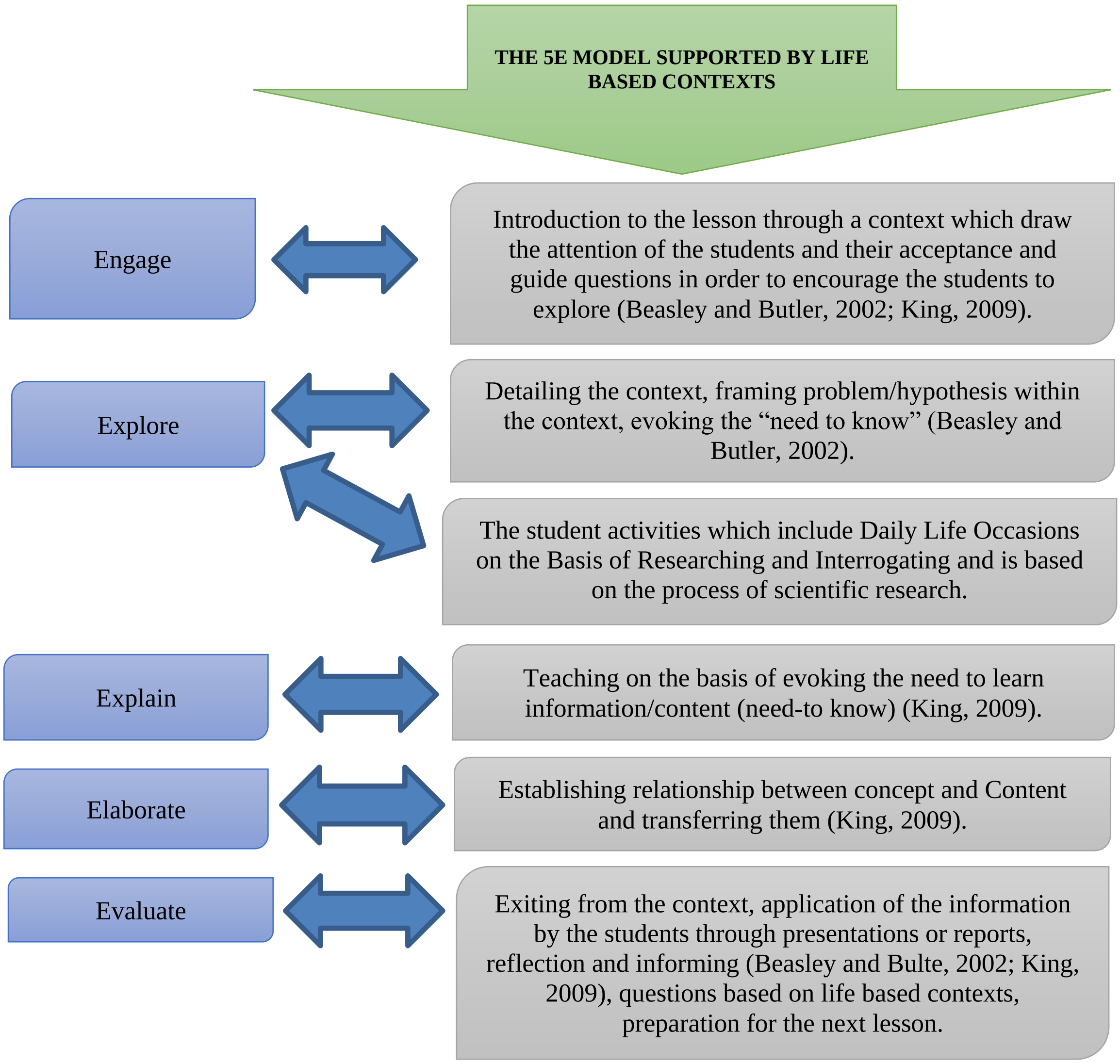

Figure 2.The stages of 5E model supported by life based contexts

Considering that the context based approach is the complementary element of the constructivist learning theory (Tekbıyık, 2010), the 5E Model which is thought to operationally function throughout it stages was preferred. The lesson plans based on Life/Context Based Learning Approach were functionalized within the framework of Contextual Structurism and based on research interrogation perception. While designing the stages of 5E Model, the elements constituting the basis of the Life-Based Teaching Approach were reflected into the stages of 5E Model in organizing the "functions of the context". Especially, the organization of the context employed in the development of the lesson plans in the stages of 5E Model and the function of the context were paid attention. In order to configure the context in the organization of the stages of the 5E Model and structuring teaching at every stage of the 5E Model, the stages in the model of King (2009) which he adapted from Beasley and Butler's

(2002) context based model were reflected onto the stages of the 5E Model and integrated. The flow diagram where the basic elements regarding the process of designing 5E Model Supported by Life-Based Contexts was illustrated in figure 2. The lesson plans developed in the 5E Model Supported by Life Based Contexts within the framework of the research were applied considering the timing process mentioned in the annual lesson plan in the teaching program of the unit of Force and Energy. In four classes chosen for the application, the researcher (the first author) conducted the research herself. Moreover, the science teacher participated the lessons along with the researcher who conducted the actual application as an observer.

Analyzing of Data

Scoring Concept Maps

The Force and Energy Concept Maps were scored by a Science Education expert together with the researcher. The Force and Energy concept maps developed by the students were scored using the "the criteria-mapped relational mapping method" according to the criterion concept maps created by experts (McClure and Bell, 1990; McClure, Sonak and Suen, 1999).

Table 3. Force and Energy concept maps inter-rater t-test results

Tests	Scorers	*N*	Mean	*SD*	*T*	*df*	*p*
Energy	1. Scorer	80	26.90	9.05	.453	58	.446
	2. Scorer	80	25.87	8.62			
Force	1. Scorer	80	9.43	1.92	.276	58	.784
	2. Scorer	80	9.30	1.82			

According to table 3, no statistically significant difference was found between raters' score assignment status for both tests ($t_{58} = 0.453$, $p>0.05$; $t_{58} = 0.276$, $p>0.05$). In other words, the scores assigned by the raters independently for each test are quite similar to each other. The correlation between the scores assigned by the raters is presented in table 4.

Table 4. Correlation coefficients between scores assigned by raters

	Correlation	*p*
Force Concept Map	0.971	.000
Energy Concept Map	0.978	.000

*p< .05

According to Table 4 when the correlation between the scores assigned by the raters is examined, it is observed that there is a high level relationship.

The Analysis of the Data Related to the Equivalence of the Experimental and Control Groups

First of all, the general grade point averages of the students at the 6.th grade in the experimental and control groups who participated in the research and the final grade point averages of science course were analyzed in terms of equivalence. In this context, the normality hypothesis was achieved. Then, the average scores of experimental and control groups through independent t-test were analyzed in order to test whether there is a significant difference between the general grade point averages of the students at the 6.th grade in the experimental and control groups and the final grade point averages of science course. The results of independent t-test were given in table 5 and table 6.

Table 5. The results of independent t-test of general grade point averages of the students at the 6.th grade in the experimental and control groups

Group	*n*	Mean	*SD*	*T*	*p*
Experimental	41	71.53	14.92	-.611	.419
Control	39	73.54	14.47		

**p>0.05*

Table 6. The results of independent t-test of the final grade point averages of science course of the students of the 6.th grades

Group	*n*	Mean	*SD*	*T*	*p*
Experimental	41	66.73	14.42	-.892	.423
Control	39	69.83	16.64		

**p>0.05*

When the table 5and table 6 are analyzed, it can be observed that there is no significant difference between the general grade point averages of the students at the 6.th grade in the experimental and control groups which were included into research according to the results of independent t-test and the final grade point averages of science course. It can be stated that experimental and control groups are equal in terms of the determined characteristics. Nevertheless, the equivalence of the experimental and control groups was analyzed in terms of the implemented pre-tests. In this sense, the results of ANOVA related to the Life Based Concept Test and Force and Energy Concept Maps which are applied as a pre-test in the experimental and control groups were presented in table 7.

Table 7. The Anova results of pre-tests of experimental and control groups

Tests	Variance Resource	Total of Squares	*df*	Total of Squares	*F*	*p*
Life Based Concept Test	Inter-groups	0.081	1	.081	0.008	.930
	In-groups	805.869	78	10.332		
	Total	805.950	79			
Force and Energy Concept Maps	Inter-groups	1.604	1	1.604	.029	.864
	In-groups	4259.283	78	54.606		
	Total	4260.887	79			

When table 7 is analyzed, it can be seen that there is no significant difference between pre-test scores of Life Based Concept Test ($F_{(1, 79)}$= .008 p>.05), total pre-test scores of Force and Energy Concept Maps ($F_{(1, 79)}$= .03, p>.05) in terms of the students' existence in either experimental groups or control groups . In conclusion, it can be stated that the experimental and control groups are equal in terms of pre-tests.

The Analysis of the Data Obtained from Experimental Application

The issue whether there is a significant difference between the post-test scores of Life Based Concept Test and the post-test scores of Force and Energy Concept Maps according to the variant of group (experimental/control) in order to avoid the increase in the error type 1 was analyzed after integrating and one-way MANOVA analysis was employed. MANOVA is a strong and multivariate statistics which is employed in experimental and scanning researches (Büyüköztürk, 2007; p: 138). Although the number of dependent variants is two or more, the number of variants in one-way MANOVA is only one. The statistical theories required for the One-way MANOVA analysis for one independent (Teaching Method) or two dependent variants were tested. Related to the analysis of covariance matrices, Box's M test was conducted. The results of the test indicated that the MANOVA analysis could be conducted and variance-covariance matrices of the dependent variants were distributed equally. Thus, the hypothesis of equal distribution of covariance matrices which are among the basic hypothesis of multiple variance analysis are satisfied. Levene's Test results related to the homogeneity of variances were analyzed and it was found that the significance of the values of Levene's F test were higher than the boundary value, 0.5. This value indicates that there is no significant difference between the groups in terms of the distribution of error variances of the dependent variants related to the determination of the homogeneity of error variances and the variances are homogenous.

The post-test score averages of Life Based Concept Test and the averages of the post-test scores of Force and Energy Concept Maps were analyzed through One Way MANOVA in order to determine whether they differ according to the variant of group (experimental/control). The results of MANOVA were given in table 8.

Table 8.The Results of MANOVA for the post-test score averages of life based concept test and force and energy concept maps for experimental and control groups

Test	Group	*n*	Mean	*SD*	*df*	*F*	*p*
Life Based Concept Test	Experimental	36	22.05	2.22	1-69	100.70	0.000
	Control	35	15.74	3.02			
Force and Energy Concept Maps	Experimental	36	65.27	13.53	1-69	68.52	0.000
	Control	35	37.94	14.28			

In table 8, the results of one way MANOVA which was conducted according to the post-test score averages in the experimental and control groups. When those values are considered, the averages of post-test scores of Life Based Concept Test ($F_{(1, 69)}$= 100.70 $p<.05$) and the averages of post-test scores for Force and Energy Concept Maps ($F_{(1, 69)}$= 68.52, $p<.05$) display significant difference in terms of the students in the experimental groups and those in the control groups. In other words, the students in the experimental group have higher averages of score in the tests where "the Conceptual Understanding Levels" are determined through the Life Based Concept Test and Force and Energy Concept Maps.

Results and Discussion

In this study, the conceptual understanding levels of the students in the 7.th grade who complete the activities in experimental and control groups in the unit of Force and Energy were determined through employing two different measurement techniques such as Life Based Concept Test and Concept Map. According to the obtained data, the students in the experimental groups where the unit of Force and Energy is conducted through lesson plans developed in the 5E Model Supported by Life Based Contexts achieved statistically and significantly higher scores in terms of the scores of both Life Based Concept Test and concept maps when compared to the students in the control groups where teaching process is conducted according to methods of transferring and presenting the information. From this point of view, it can be stated that the teaching process designed in the 5E Model Supported by Life Based Contexts is more effective than the methods implemented in control group in students' developing conceptual understanding.

When literature is analyzed, it is possible to see some studies which deal with Life/Context Based Learning Approach and 5E Model support and develop conceptual understanding. For example, Kistak (2014) determined the conceptual understanding levels of the students in the unit of Sound through conceptual achievement test in the study conducted with 5E method based on life based learning and found out that the errors of some concepts decreased to some degrees. Considering the gaining of the unit of Energy in the Teaching Program of the course Physics in the 9.th Grade of Secondary Education, Tekbıyık (2010) developed lesson materials for the students and teachers in accordance with 5E teaching model through a context based approach and determined that those materials increased the achievement of conceptual understanding levels of the students. Similarly, the findings of this research overlap with the findings which prove that life based teaching applications(Akpınar, 2012; Bennett and Lubben, 2006; Barker and Millar, 1999; Çekiç Toroslu and Güneş, 2009; Glynn and Koballa, 2005;King, Winner and Ginns 2011; Peşman, 2012; Tekbıyık, 2010) and the activities conducted through 5E Model (Akbulut, 2013; Artun and Coştu, 2013; Demirci and Yavuz 2009; Niaz 2002; Panizzon 2003) all provide conceptual understanding, conceptual achievement or conceptual transformation.

Even conceptual understanding level is measured through different measuring instruments other than those employed in the research concluded through life based learning perception and 5E Model in the literature, it is possible to obtain a result which overlaps the findings of the researches in literature. In this research, the effects of 5E Model Supported by Life Based Contexts on the conceptual understanding levels among the students can be explained in two ways. The first of them is the teaching method fictionalized in the research is about 5E Model. In his study which he presented his evaluations related to 5E Model, Bybee (2014)pointed out that the *stage of Engage*of the method related to conceptual understanding provides opportunity to informally determine the conceptual errors among the students, *the Stage of Explore* provides a base for a common activities where a conceptual transformation is facilitated based on the definition of current concepts (misconcepts etc.), processes and skills, *the Stage of Explain* focuses the students on a definite point of their experiences at the stages of Engage and explore and provided advantages to them in developing their conceptual understanding while the students adapt the concepts and their skills into new situations through new experiences at *the Stage of Elaborate* and develop a deeper and broader perception. Within the context of determining misconcepts in accordance with the evaluations of Bybee (2014) who is one of the designers of 5E Model, it can be stated that

5E Model is effective in students' developing a deeper perception related to the concept of physics as a method which arranges and coordinates the learning process in terms of providing activity based conceptual transformation and transferring the learned concepts into different environments. The 5E Model is a teaching model which is based on the theory of Piaget and is figured with the constructivist theory and this model encourages the students for experience-based learning through motivating them and drawing their attention. Thus, students actively participate to the high level thinking process. This teaching process which requires teacher to develop in structuring the learning environment enables students develop a critical thinking-based analytical type of relation with the content to be learned (Kanlı, 2007). It can be stated that the 5E Model and the ideational processes the student encounter related to the scientific concepts are effective in developing a strong conceptual structure.

Another dimension of the research which is thought to be effective in developing the conceptual understanding levels of the students is the teaching process conducted based on real life contexts. It was emphasized that the 5E Model Supported by Life Based Contexts was structurized based on Contextual Constructivism and research-interrogation perception and its function in the elements which constitute the principles of Life/Context Based Teaching Approach in organizing the "function of the context" while designing the stages of the 5E model was pointed out. Barker and Millar (1999) asserted that presenting scientific concepts through daily events increased the motivation and learning desire of the students. Related to understanding the context during the stage of arising curiosity, increasing the learning motivation of the student provides the student feel the need of knowing (need to know) the scientific concept in order to understand the context. Thus, the student operates his skills of scientific processes (Schwartz, 2006) such as accessing information, interpreting information, analyzing, and giving decision in order to learn the concept through the context in the stage of exploration. During this process, teacher should introduce and explain the scientific opinions and concepts when necessary (Campbell et al., 2000). One of the key points of the model in establishing a strong perception for scientific concepts is establishing relations and connections between the concepts and real life contexts and transferring those connections from one field into another (King, 2009). The activities to establish the relations between Concept and Context were configured within the stage of expanding. This connection between the concept and real life context continues in the form of transferring the concept into other daily life contexts and contributes to the correctly configuration of the connection of the concept with other concepts. In fact, it is observed that the students in the experimental group are more successful in transferring the concepts into other daily life contexts and establishing correct connections among the concepts according to the results of the research observed from both life based concept test and concept maps. When the real life contexts-based learning approaches is considered from the perspective of the assessment of teaching, the evaluation questions which were prepared in accordance with real life contexts in order to understand whether students understand the concepts or not have importance in establishing a base for the courses in the future (Bennet and Lubben, 2006) has great importance. In fact, the evaluation activities developed based on real life contexts were employed during the Evaluation Process of Life Based 5E Model. Benckert (1997) expressed that classical questions employed in the evaluation of the scientific concepts idealize the science and, for that reason, the science fail in having the students and teachers establish a connection with real life. It is emphasized that the questions which consist of daily life occasions carry the students into various processes of thinking without leading them to memorizing and enable the students concretize the questions within a context and animate them in their minds (Bellocchi, King and Ritchie, 2011; Rennie and Parker, 1996). Burbules and Linn (1991) determine that the reason for the failure in solving the contexts encountered in daily life is the failure of students in transferring the information learned at school into daily life and different occasions. Accordingly, the real life contexts-based questions were employed both during evaluation process of the teaching model implemented in the research and in the concept test which is used for determining the conceptual understanding levels. At this point, it can be stated that developing evaluation activities of the teaching model based on the real life contexts contribute to the students in implementing the concepts they learn during the courses into different contexts and be more successful. In line with this, it can be pointed out that the 5E Model Supported by Life Based Contexts can be regarded as another factor which contributes to the development of conceptual understanding among the students in terms of organization, function and configuration of this model from the stage of Engage to the stage of evaluate.

Through the experience obtained from this research, we can point out that a correct conceptual perception was developed upon a person displays consistent and fault-free structures of information and when we implement those informational structures in the real life contexts which consist this information structures and turn them functional. Accordingly, the aspects of lesson plans prepared according to 5E Model Supported by Life Based Contexts in students' developing their conceptual understanding;

- ✓ Conducting the teaching through the contexts which facilitate the transfer of information,
- ✓ The organization of the Contexts at the Stages of 5E,
- ✓ The issues discussed in integrating Life Based Approach and Constructivist approach,
- ✓ The activities of stage of Explore and Elaborate related to Establishing Concept-Context Relation.

Different from the other researches, both Life Based Concept Test which consists of daily life contexts and concept maps were employed together in this research in order to determine the effects of life based learning perception within the context of conducting all the teaching and evaluation activities in an integrity on the conceptual understanding levels. Starting from this point, it is thought that discussing the employment of different measuring techniques in the research for the interpretation of conceptual understanding. The experimental groups in the research who learn the unit of Force and Energy through Life Based 5E Model were found more successful than the control groups in terms of the scores where conceptual understanding is evaluated in the dimension of Life Based Concept Test. In the same time, the results obtained from the concept map reveal that the students in the experimental group display a stronger conceptual structure in establishing relations between the concepts. Hence, De Jong (2006) stated that the failure of the context based approach in the students' understanding the scientific concepts results from the failure in establishment of the relationship between the concepts employed by the students and teachers and the concepts related to the contexts. It can be stated in this research that the findings obtained as a result of measuring the conceptual understanding in the unit Force and Power among the students via life based concept test require the preparation of the evaluation instruments in accordance with the nature of teaching methods which are implemented and the contexts and the organization of the contexts selected for the configuration of the teaching methods and the development of Life Based Concept Test were effective in transferring information.

Another measuring instrument employed in the evaluation of the students' understanding the science concepts through Life Based Concept Test is the Force and Energy Concept Maps. The experimental groups who learn the unit Force and Energy through 5E Model Supported by Life Based Contexts were found more successful in terms of establishing correct relations between science concepts and setting a hypothesis when compared to the control group. According to Ruiz-Primo et al., (1997), understanding a topic means having a conceptual structure which was strongly associated with that topic. Trowbirdge and Wandersee (1998) employed the concept map in order to observe the different in the understanding of the students related to the topic and found out that the concept map is an extremely delicate for measuring the changes in the structure of information (p.54). In the literature, there are numerous studies where different techniques of establishing concept maps and concept maps are employed as evaluation instruments (İngeç, 2009; İnaltun, 2013; Nakipoğlu and Ertem, 2010; Plummer, 2008; Ruiz-Primo et al., 2001; Ruiz-Primo et al., 1997; Tokiz, 2013; Yin and Shavelson, 2008). In his study related to the revealing the conceptual understanding levels of the students through concept maps, Tokiz (2013) points out that the students were able to insert the concepts related to force successfully into the blanks in the maps but they couldn't explain these concepts and the relations between those concepts or they couldn't exemplify their employment in technology and their significance in daily life. In this research, the students were given a list of concepts which were determined according to definite criteria on the topic of Force and Energy and thus it was aimed to reveal the conceptual structures of the students (McClure Sonak and Suen, 1999) and determine their level of defining a concept through its relations with the other concepts (Shavelson, 1974). The study of İnaltun (2013) which he observed the conceptual understanding of the students through the technique of establishing concept map from the zero-point display parallelism with the findings of this study in terms of employing the conceptual maps as an instrument in determining conceptual understanding. Accordingly, a concept test developed based on the contexts in conformity with the nature of the applied teaching method and concept maps were employed together considering the limitedness of interpreting the conceptual understanding of the students through a single test; and it was concluded that 5E Model Supported by Life Based Contexts improve conceptual understanding when the results obtained from the both tests are interpreted together.

The findings of the studies in the literature which deal with life/context based approach and 5E Model together or separately overlap with the findings of this research. Different from the researches in the literature, however, different measuring instruments were employed together in this research in terms of conformity to the nature of the implemented teaching method and the integrity of method and assessment was considered. When the obtained findings are assessed accordingly, it may be seen that the teaching process conducted based on real life contexts develops conceptual understanding on condition that when they are measured through different measurement instruments in conformity with teaching method. It was concluded that reviewing the studies which deal with conceptual understanding in terms of determining them in parallel with the applied teaching methods and employing different measurement instruments would be useful. Moreover, it is suggested that

Teaching Programs of the Science courses should be reviewed in terms of the applications in the course books and the employed measuring instruments.

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Evaluation of Students' Use of Visual Learning Representations in Science Classes: A Case Study from Turkey

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Abstract

The aim of this study was to analyse the kinds and frequency of visual learning representations within 8th grade students' notebooks for science classes. As part of the research, 93 science notebooks which belonged to students from 13 secondary schools in Kars Province (the east of Turkey) were collected at the end of the academic year in 2018. Document analysis, a qualitative research strategy, has been adopted and content analysis technique was used to analyse the collected documents. The results showed that the visual learning representations recorded on students' notebooks were notably different from one unit to another and from one school to another. Moreover, it has been observed that students did not make frequent use of visual representations whilst learning the content. Additionally, the visual learning representations in students' notebooks mostly consisted of the representations used by teachers during classes. These findings suggest that science teachers might have not been successful enough in guiding students to incorporate different visual representations into their learning processes for a better understanding of science subjects.

Introduction

In today's world, the decision makers, who decide on educational policies, put the question of "How can we increase student's academic success in science education?" at the top of their agendas. Reaching the standards which could be the answer to this question can, in fact, be described as achieving the learning outcomes which would respond to the requirements of the 21st century. And it is necessary to evaluate the kind and quality of teaching activities utilized in science classrooms in order to remove the obstacles of achieving those outcomes. In relation to this, the written documents that include the records of teaching activities in science classrooms (i.e. notebooks, lab reports, activity forms, and diaries) are one of the most effective means of interpreting students' performance and learning outcomes (Ruiz-Primo, Li, Shavelson, 2001). This is because such documents are fundamental sources in which students keep records of their own learning processes and representations. In line with this, we should identify students' strengths and weaknesses in order to be able to increase their success rates in science subjects. On a different note, in science classes, students' academic performance is generally assessed based on exams, homework, and classroom observations. More specifically, traditional assessment methods that are based on written exams are prominent. The most important issue in assessment, on the other hand, is to be able to define what the evidence that can reveal students' performance is. Because, evidence that reflects students' comprehension levels should be collected in order to introduce and integrate quality education designs into teaching/learning processes (Wilson, 2008). Based on such evidence, assessments with regards to students' learning behaviours can also provide a opportunity to science teachers to develop their practice, as teachers would have an opportunity to evaluate the outcomes of their efforts in the form of student success (Forsberg & Wermke, 2012).

The use of traditional assessment methods has a number of limitations in analysing and supporting student learning in science education. Assessments that are conducted based on traditional assessment methods make it more difficult to determine the areas that students experience difficulties in learning (Nitko, 2004; Bahar, Nartgün, Durmus, & Bıcak, 2009). Moreover, assessments conducted based on such methods frequently fail to properly guide teachers' decisions (Areglado, Clemmons, Cooper, Dill, & Laase, 1997). Those traditional assessment methods should be replaced by others which would allow teachers to collect more concrete evidence of student learning (Reed, 2012). In this sense, student notebooks, experimental designs, laboratory practices, teaching scenarios based on the solution of real world problems, team work, and individual interviews with students are considered to be the most effective ways of assessing students' science understanding (National Science Teachers Association [NSTA], 2011). Those ways that might be used for assessment which allow the opportunity to better analyse the barriers to learning in science subjects have different characteristics from traditional assessments. Such methods allow the collection of information, which has more explanatory power, from teachers and students. Furthermore, such evaluation are focused on analysing students' thinking about science subjects at a deeper level unlike traditional methods which simply define student thinking as "right" or "wrong" (Ruiz-Primo et al., 2001). It has been asserted that one of the most effective innovative assessment tools for developing students' comprehension of science subjects and realizing the 21st century learning goals are the student notebooks (Reed, 2012). Science notebooks are crucial sources in which in and out of class pedagogical and content interactions are recorded during teaching/learning processes. This is because notebooks are the most concrete records of the scientific facts that students learn and the learning processes they have been through whilst learning those facts (NSTA, 2008).

National Research Council (NRC, 2007, 2012) emphasizes the importance of students' recording their observations, opinions, views, and models in their notebooks for a better learning from the moment they start learning within the framework of K-12 education. Moreover, the importance of encouraging students to create diagrams and visualise data and their observations via tables in addition to the texts recorded in their notebooks is highlighted (Lee & Jones, 2017). Notebooks depict students' work in relation to their learning and classroom experiences over the course of their education. Moreover, those notebooks are valuable records that contain reflections of teachers' teaching practices and define students' science learning (Campbell & Fulton, 2003; Madden & Wiebe, 2013). Information included in students' notebooks, depending on attendance to classes, can be traced back to course books or teachers' improvisations (Yau & Mok, 2016). According to Ruiz-Primo, Li, Ayala, & Shavelson (2004), examination of the information within student notebooks is one of the most effective assessment methods that can be used to select activities that would increase student performance. Moreover, Baxter, Bass and Glaser (2000) found that science notebooks reflect what students do and what teachers focus on during classes. More specifically, the notebooks contain the evidence in relation to teachers' progress in terms of the curriculum as well as the pedagogical interactions with their students (Ruiz-Primo & Li, 2013). The work contained in science notebooks is a rich source of assessment that can provide information on students' scientific thinking and practice (Aschbachar & Alonzo, 2006; Ruiz-Primo, Shavelson, Hamilton & Klein, 2002). Akaygun and Jones (2014) have highlighted that the texts and/or drawings in students' notebooks represent the most practical form of communication to express student's understanding of science subjects. In addition to written proofs that represent students' understanding of science, notebooks are also considered as the most valuable source that can be used as an indicator of the opportunities for students' visual learning practices (Gilbert, 2010; Ruiz-Primo & Li, 2004).

Notebooks help students to individually reflect student thinking via visual learning tools such as drawings, diagrams, tables, and graphics (Nesbit, Hargrove, Harrelson, & Maxey, 2004). As noted in the Next Generation Science Standards (NGSS), in addition to writing, the use of drawings, models, diagrams, and tables are critical to allowing students have a more effective scientific communication (NGSS, 2013). The review of related literature suggests that visual representations are described as figurative representations. Those figurative representations include learning artefacts such as pictures, schemata, graphics, photos, colouring, concept maps, diagrams, tables, and various symbols (Moline, 1995; Petterson, 2002; Vekeri, 2002). Coleman, McTigue and Smolkin (2011) point out that the use of visual representations for teaching purposes can play an important role in correctly explaining and exemplifying/illustrating new and abstract concepts in science. For example, the use of visuals in teaching about bacteria which are microscopic living organisms can facilitate student understanding. Therefore, the use of visual representations can be considered as a teaching strategy which develops children's scientific communication skills (Mishra, 1999). Researchers note that the integration of visual representations (picture, diagram, drawing, table, graphic, map, models, and so on) into the curriculum can help students to relate new knowledge to a structured product, thereby, facilitating the comprehension of content (Chang, 2012; Cox, 2005; Danish & Enyedy, 2007; Van Meter & Garner, 2005; Van Meter et al., 2006; Wilson & Bradbury, 2016).

Students' science notebooks can differ in terms of visual learning practices from one lesson to another and from one student to another. Nevertheless, the analysis of student notebooks of a classroom facilitates the identification of the visual learning practices in a specific lesson. When student science notebooks within a classroom are analysed for the contents of a science subject, if there is not any evidence suggesting that a visual learning activity has taken place, then, it can be said that the possibility of carrying out that particular activity is low. In other words, the analysis of student notebooks in a given classroom would reveal what kind of visual learning practices have been carried within and outside that particular classroom. The visual learning means have moved important role for students' understanding to contents of intense and difficult in secondary science class. Because of, in terms of improving the science education quality is quit essential, to make questioning on how shape, the use frequency and sorts of learning process with this visual means in secondary school science class. Despite this significance to been expressed, studies which search case of usage of visual learning means have specially sighted to not be located in science class at Turkey. With this in mind, the current study aimed to analyse the visual learning practices within the science notebooks of 8th grade students at the end of the academic year. Moreover, the authors focused on the kinds and frequencies of the visuals within 8th grade students' science notebooks. This study provided an opportunity to explore the extent and kind of visual learning artefacts within 8th grade students' notebooks in secondary schools in Kars, a province located in North East of Turkey.

Science Notebooks as an Assessment Tool: Review of Literature

Writing is not only an important means of communication, but it also helps people develop, regulate, and strengthen their ideas. In science, writing serves as a tool to communicate scientific ideas and findings to others. Most importantly, writing is a fundamental part of scientific processes (Morris et al. 2007). The adventure of science notebooks has started in medieval ages, at that time, the notebooks were tools in which, especially, alchemists have noted down their discoveries about mystical stones using drawings (Crosland, 2004). The analysis of scientists' research notebooks has revealed valuable information regarding how science was done (Holmes, Renn, & Rheinberger, 2003). Since those times, notebooks have become sources to understand science and record and interpret ideas. Throughout the history, scientists have used science notebooks to record their ideas and experiments. Those notebooks revealed information about their authors' thinking and the scientific processes they followed (Tweney, 1991). In time, science notebooks have become tools that have been used by not only scientists but also students-inexperienced researchers- who develop their scientific understanding in classes. Similar to scientists, students use their notebooks to record problems, laboratory activities, their observations, and the outcomes (Baxter, Bass, & Glaser, 2000). Like scientists, students are responsible for taking notes in order to guide their learning and they should be encouraged to learn by recording their ideas, procedures, and results on their notebooks, just like scientists (Cole, Wilhelm, & Yang, 2015).

Shepardson and Britsch (1997) have noted that written reflections are an important tool to develop students' learning processes and their opinions. Students' written thoughts open a window into their thinking processes (NSTA, 2008). In this sense, it is important to support various note taking techniques to allow students develop skills necessary to regulate information. In this sense, student notebooks play a central role in allowing students develop such skills (Eddy, 2018). The notebook writing is one of the factors that support student learning in science classes. Writing represents a source that allows students display individual learning products in science subjects (Glen, 2008; Glen & Dotger, 2013). For deep learning to occur, students should be involved in processes in which they create learning products through writing (Prain & Tytler, 2012). The texts in students' science notebooks characterize the processes resulting in conceptual understanding. Furthermore, the writing procedures in science are considered as knowledge building processes (Gunel, Hand, & Prain, 2007; Hand, 2017; Hand, Gunel, & Ulu, 2009; Hand, Wallace, & Yang, 2004; Huerta & Garza, 2019; Huerta, Lara-Alecio, Tong, & Irby, 2014; Pelger & Nilsson, 2016; Rouse, Graham, & Compton, 2017; Ruiz-Primo et al. 2004; Yore, 2003). Additionally, many researchers highlight the importance of writing on notebooks in order to support the development of students' academic writing and language skills (Butler & Nesbit, 2008; Grimberg & Hand, 2009; Keys, Hand, Prain, & Collins, 1999; Morrison, 2008; Rivard & Straw, 2000).

Science notebooks are records of students' written opinions and visual artefacts such as tables, models, diagrams, and graphics. Moreover the notebooks include student reflections, questions, hypotheses, claims based on evidence and –most importantly- the new concepts that they learned. Student notebooks make significant contributions to the development of students' conceptual understanding and communication skills during learning processes (Morrison, 2008; Reed, 2012). Therefore, a science notebook is a central location where language, knowledge, and experience are brought together to create understanding. If a science notebook is used effectively, then, it can serve as an important source of data both for the student and the teacher. Moreover, science notebooks could become a direct measurement as well as a formative assessment tool of student understanding. Science notebooks are also individual records in which student questions are formulized and serve the aim of reflecting the level of progression of research. Student notebooks record the scientific procedures such as installing hypothesis, developing an action plan, recording observations and data, proving claims, and creating a report of findings (NSTA, 2008). Recent studies point out to the necessity of approaching language and writing as inseparable parts of inquiry-based learning in science (Jang & Hand, 2017; Pelger & Nilsson, 2016; Seah, 2016; Williams, Tang, & Won, 2019).

Research studies continuously showed that taking notes on notebooks has an important role on students' effective learning of science subjects. Notebooks support the development of skills such as writing, recording data, documenting activities, organizing information, presenting results, and reflection which are crucial in science. Notebooks encourage students in applying, making sense of, explaining, and developing recently learned knowledge. Moreover, notebooks play an important role in learning processes since they reflect students' individual understanding, opinions, and/ or feelings (Reed, 2012; Ruiz-Primo et al., 2004). Science notebooks are defined as a rich portfolio of information that consists of recordings of students' answered or unanswered questions, procedures that were followed, materials used, the data that was collected and organized, and other data collected from different sources (Nesbit, Hargrove, & Fox, 2003). Many studies in the last two decades have suggested that student notebooks should be used effectively as part of science teaching (Ruiz-Primo & Li, 2004; Ruiz-Primo et al., 2004; Aschbacher & Alonzo, 2006). The science notebooks of the 21st century are a popular source for documenting student work and ideas at secondary school level (Fulton & Campbell, 2014; Fulton, Peak, & Taoka, 2017). Furthermore, quite a few number of researchers and educators believe that the use of students' science notebooks as an assessment tool to measure academic success and form educational strategies is more effective compared to traditional assessment tools (Nesbit, Hargrove, Harrelson, & Maxey, 2004; Ruiz-Primo & Li, 2013). According to Aschbacher and Alonzo (2006), science notebooks should be considered as important assessment tools for at least two reasons:

1. Notebooks are an embedded part of the curriculum. Therefore, they are a source of data readily available to teachers. Teachers, in order to be able to make judgements relating to their teaching practices, can gain information from student notebooks at any given time without the need for extra time or expertise.
2. Notebooks are a direct measurement of students' understanding of the science curriculum and, therefore, are especially important for the goals of formative assessment.

Ruiz-Primo and Li (2013) define teacher feedback as an important component of formative assessment practices in classrooms. In order to be able to give effective feedback, teachers should firstly understand where they stand in terms of realizing learning objectives and science notebooks can provide such valuable information. The interpretation of the information within those books provides clues for teachers that can facilitate student learning. Student work on science subjects in their notebooks is a rich form of formative assessment that reflects their scientific thinking and practices (Aschbachar & Alonzo, 2006). Formative assessments are strong tools that can guide students. Therefore, student notebooks are rich sources of data for formative assessment (Shelton et al., 2016). As an assessment tool, student notebooks can be used at two levels: a) at individual level, the notebooks can provide evidence of students' performances during the class and b) at class level, the notebooks can provide evidence of opportunities for student learning (Ruiz-Primo et al., 2002; Ruiz-Primo & Li, 2004).

The strongest quality of science notebooks is the fact that they provide real records of students' scientific thinking and provide accurate feedback regarding their learning. Information gathered from science notebooks provide an accurate record of each student's level of understanding during thinking and research processes. Teachers can use such information in order to understand what students think, identify their strengths and weaknesses, and why they make mistakes. The information collected from notebooks should be used to develop classroom practices, correct misconceptions, and allow students develop a deeper understanding of the content. Another advantage of the information collected from students' science notebooks is that it includes clues regarding students' success in other subjects. That is to say, students' science notebooks can also be used as assessment tools to measure students' mathematics and language (i.e. written language) skills (Huerta, Tong, Irby, & Lara-Alecio, 2016; Nesbit et al. 2004). Although it is commonly believed that science and writing are two separate subjects, writing is considered to be the basis for most scientific practices (Fulton, Paek, & Taoka, 2017; Paek & Fulton, 2017). Effective use of science notebooks does not only facilitate students' development of a deeper conceptual understanding, but it can also facilitate the development of academic writing skills- one of the problems teachers are faced with nowadays- by combining science and language skills (Klentschy, 2006). There are many research studies which present the value of student notebooks as an assessment tool in science (Aschbacher & Alonzo, 2006; Huerta, Lara-Alecio, Tong, & Irby, 2014; Huerta, Irby, Lara-Alecio, & Tong, 2016; Ruiz-Primo et al., 2004; Shelton et al., 2016).

Sugrue, Webb and Schlackman (1998) remark that assessments carried out using student notebooks are far more effective than traditional assessments conducted using multiple-choice questions in revealing student misconceptions and more. Various forms of assessment are currently used to identify the effects of science education reforms on student success and understanding. Sit-down exams, oral exams, tests, and project assignments are among those methods that are placed at the top of the list. Apart from those, the use of student notebooks, which represent a very unique source of information, as a summative assessment tool has often been ruled out. What makes this kind of assessment unique is the fact that the information within the notebooks provide valuable clues regarding both teachers and students pedagogic behaviours. Science notebooks are potentially rich sources including student artefacts. The notebooks allow students to record their experiences of science classes throughout the term. Those experiences in science are shaped by teaching practices. Therefore, the notebooks can serve as a useful tool to investigate how students interpret teaching activities throughout science classes during the term. The analysis of international research on students' science notebooks reveal that studies have generally focused on the texts within students' notebooks (Huerta et al., 2016; Ruiz-Primo & Li, 2013; Shelton et al., 2016; Wickman, 2010). On the other hand, there seems to be a scarcity of research on the visual learning elements within students' science notebooks (Cole, Wilhelm, & Yang, 2015; Fulton et al., 2017; Nesbit et al., 2004). To the best of our knowledge, there has not been any study conducted on visual representations located in students' science notebooks in Turkey. There are only a few studies which focused on pre-service science teachers' notebooks (Calıskan, 2014) and diaries (Toman & Odabası Cimer, 2014).

Research Questions

The need of the current study arises considering the importance of science notebooks providing written and visual support to learning processes. As such, the research questions that guided the present study were:

1- What kinds of visual representations are used in 8th grade student science notebooks? What are their frequencies of use?
2- Do visual representations change from one class unit to another?
3- Do visual representations change from one school to another?

Method

Research Design

The present study is a case study that was conducted in primary schools in the Kars Province in eastern Turkey. The aim of the study was to investigate the contents of 8th grade students' science notebooks which were accumulated throughout an academic year. Case studies focus on a deeper analysis and description of everyday life phenomena and/or events (Merriam, 2002; Yin, 2009). The present study adopted an "embedded multiple case study" design. Embedded multiple case study designs investigate multiple cases each of which may include multiple sub-units of analysis. Such designs allow for comparison and contrast between cases (Creswell, 2013; Simsek & Yıldırım, 2008). In this context, the study is have analyzed case of usage visual learning means of middle school 8th grade students visual learning means both at school more than one and in terms of different students in this school.

Materials and Data Collection

The data analysis technique utilised in the present study was document analysis which is qualitative in nature. The literature defines documents as "physical data". Documents represent objects that have been created by people. Therefore, documents can contain important information about individuals. Analysing written and visual documents regarding the research questions can provide an opportunity to make rich and comprehensive interpretation (Bas & Akturan, 2008). The documents analysed in the present study were selected from 93 8th grade student notebooks that were collected voluntarily from 13 different secondary schools located in the Kars Province in the east of Turkey in 2018. Although the total number of secondary schools in Kars city centre is 22, nine of those schools did not provide us with student notebooks, and were not included in this study. However, different school profiles (i.e. low, medium, and high achieving schools) were all represented in this study.

During school visits, all science teachers in the 13 participating schools explained that they required students to regularly take notes in their notebooks in classes. Student notebooks that were analysed in this study were collected at the end of the 2017-2018 academic year. From the 93 science notebooks collected (see Appendix A), 37 were selected (see Appendix B) randomly for analysis (three notebooks each from 11 schools, and two notebooks each from two schools). The reason for selecting only two notebooks in those two schools was the fact that the other notebooks collected from those schools were illegible causing them to be rather inadequate for document analysis. Details relating to the notebooks analysed in the study are provided in table 1.

Table 1. Schools participating in the study and the distribution of the notebooks

School code	Notebook number	Notebook code
A	3	A2, A6, A9
C	3	C3, C6, C7
D	3	D1, D5, D9
E	3	E1, E2, E3
F	3	F4, F6, F10
G	3	G1, G5, G6
I	3	I2, I5, I6
K	3	K3, K5, K6
M	2	M1, M3
S	3	S1, S2, S4
T	3	T2, T4, T6
Y	2	Y1, Y2
X	3	X1, X2, X3

Data Analysis

The analysis of documents is a crucial stage in a study since the researcher(s) should interpret the contents of the collected document(s). The contents of a document should be coded into appropriate categories (Harris, 2001; Bas & Akturan, 2008). Each of the notebooks included in the study was analysed in terms of the types and frequencies of the visual representations used in each unit of the 8th grade science curriculum. Furthermore, the analysis also aimed to identify the differences between visual learning representations utilised in science classes across the schools included in the study.

Table 2. Sample coding categories of the visual representations in students' science notebooks

Code	**Description of the code**
Diagram	✓ A visual representation that establishes connections between the parts or branches of a mechanism within a schema (i.e. water cycle) ✓ A visual representation that helps us understand the working principles of an objects or see within it (Moline, 1995)
Table	✓ A visual that generally does not include pictorials and represents a structure that consists of rows and columns (Moline, 1995)
Graphic	✓ A visual representation used to present data that has been measured (Moline, 1995)
Drawing	✓ Visualising an idea on a two-dimensional background
Picture	✓ Visuals that represent how things look like in nature (Turkish Language Association [TLA], 2019)
Model	✓ Visual representations that are made to look like a certain artefact
Concept Map	✓ A two-dimensional visual representation of the relationship among concepts (Novak 1990; Novak & Cañas, 2008)
Highlighter	✓ Markings that are made using highlighters
Box	✓ A visual representation that looks like a square or rectangle and used to highlight the importance of scientific ideas
Tag	✓ A small piece of paper that is used to summarize the features of an object or idea
Scribble	✓ Notes that are not in an orderly fashion and that have been recorded randomly
Acronym	✓ A visual which utilises the first letters of texts or concepts to create a word that makes the text or concept easier to remember.
Star	✓ A visual representation that is used to highlight the importance of an idea and placed at the beginning of that idea
Bubble	✓ Circling an idea in order to highlight it
Scale	✓ A graph that is used to show measurements (TLA, 2019)
Pyramid	✓ An object that consists of a number of triangles the tops of which merge on a shared point and the bottoms of which comprise one side of a polygon (TLA, 2019)
Flow Chart	✓ A chart that is used to show the relationship between each step as well as show the direction of the relationship in order to describe a process
Formula	✓ A group of symbols that generally explain a phenomenon, law, or principle (TLA, 2019)

A total of 2889 pages in 37 notebooks were analysed for their visual content. A number of coding categories were pre-determined and based on the related literature that had previously content analysed student notebooks for the visuals used (Moline, 1995; Vekeri, 2002; Coleman & Dantzler, 2016; Tippett, 2016). Other coding categories emerged whilst previewing the data and initial visual representation codes were created. Those coding categories were further developed during the analysis. The resulting coding included a total of 18 categories (table, graphic, formula, drawing, picture, pyramid, diagram, scribble, model, scale, acronym, tag, bubble, box, highlighter, star, concept map and flow chart) for visual representations (see Table 2). Afterwards, we investigated to previous studies that focused on analysing student notebooks (Danish & Saleh, 2014; Huerta, Lara-Alecio, Tong, & Irby, 2014; Ruiz-Primo et al., 2004; Ruiz-Primo & Li, 2013). Coding examples of students' visual representations are provided in Appendix C.

Contents relating to each unit of the science curriculum in students' notebooks were separately analysed by both authors. All notebooks were coded by both authors and the frequency of the codes which emerged in the data has been represented with numbers. The comparison between the coding completed by both authors on the unit of "Light and Sound" revealed that one of the authors did not recognize the bubble visual used in one of the students' notebooks to highlight important information. Following this, the codes that both authors created for the unit of "Light and Sound" were all compared to confirm that coding. The interrater reliability index for the whole set of codes was calculated as 86 %. Moreover, another researcher independently coded the unit of "Simple Machines" for 14 notebooks and that coding was compared to the authors coding and the interrater reliability for that comparison was found to be 90 %.

Findings

This section presents details regarding the distribution of visuals in 8th grade students' science notebooks in different curriculum units, schools, and students' notebooks. The tables were created considering the visual codes that were present in students' notebooks. The findings, which were based on the analysis of the data through a total of 18 visual representation codes, differed in terms of frequency from one unit to another. The tables included visual representation codes that were only present in the related curriculum unit. Details relating to visual representations that were not available in any students' notebooks in a specific unit were added as a note under related tables.

Findings on the kinds and frequency of visual representations in student notebooks at school and unit level

Main findings about the visual representations used in 8th grade student science notebooks have been presented under the unit headings of the science curriculum. Each of the tables presented below include details regarding the schools (i.e. school codes), gender of the students who owned the notebook, number of pages that the notes cover for the unit, and the kinds of visual representations. The tables below are prepared in accordance with the units covered in the 8th grade science curriculum: Human Reproduction, Growth, and Development (Table 3); Simple Machines (Table 4), Structure and Characteristics of Matter (Table 5), Light and Sound (Table 6), Living Organisms and Energy Relationships (Table 7), States and Characteristics of Matter (Table 8), Electricity in Our Lives (Table 9), and Earthquakes and Weather Events (Table 10).

The analysis of the kinds and frequency of the visual learning representations used in student notebooks on the unit of "Human Reproduction, Growth, and Development" (see Table 3) reveals that the most frequently used visual representations were drawings which included; students' copies of teachers' drawings relating to the course content and copies of the drawings from the course book. This was followed by stars which were generally used to mark important definitions and/ or explanations. Those two visuals were present in all the notebooks that were analysed and it has been observed that they were more frequently used in a number of schools compared to others. More specifically, drawings were mainly used to represent meiosis and mitosis. On a different note, the analysis of the frequency of the use of stars show that students in School F and School G have rarely made use of those visual representations. Additionally, students in all schools, with the exception of one, have at least once made use of acronym (which is a method of learning by coding information). The analysis of other visual representations in Table 3 show that students in School C made more frequent uses of graphics in comparison to other schools.

Table 3. Frequencies of the visual representations in student notebooks for the "Human Reproduction, Growth, and Development" unit

Notebook Code	Table (n)	Graphic (n)	Formula(n)	Drawing (n)	Picture (n)	Model (n)	Acronym (n)	Box (n)	Highlighter (n)	Star (n)	Concept map (n)	Flow chart (n)
A2		1	2	4				1		10		
A6			1	12			1	2		39		
A9			2	5			1	2		11		
C3	1	4	2	15						8		1
C6	1	4	2	12						9		1
C7	1	4	2	12						5		1
D1	1		1	4	13	3				85	4	
D5	1		2	8	4	3				66	2	
D9	1		2	12	2	2	1		2	110	3	
E1	3		2	6					1	32		
E2	2		2	13				1		10		
E3	2		2	6						35		
G1	5		2	12						2		
G5	5		2	12		2		2		1	2	
G6	5		2	13		2		2	1	1	2	
F4	1		2	10								
F6	1		2	9			1			1		
F10	1		2	12			1					
İ2	1	1	1	13			1			61		1
İ5		1	1	13	2	1				65		1
İ6	1	1	1	9	2	1	1			9		1
K3	1	1	2	17	1		1	2		5	1	
K5	1	1	2	10			1			59		
K6	1	1	2	14	1		1			8	1	
M1	2	1	2	12			1		2	19		
M3		1	2	14	1					62	1	1
S1	1	2	2	13					6	33		
S2	2	2	2	13			1	1		46	1	
S4	2	2	2	13			1		8	55	1	
T2	2		1	14					1	72		5
T4	1	5	2	9				1		70		1
T6		2	2	6			1		20	48		
Y1	2		2	5					3	14		1
Y2	3		2	10			1	2		7		
Z1	1	1	2	9				1	1	14		
Z2	3	1	2	11			1			7		
Z3	2	1	2	8						2		

Note: The following visual representations were not present in any students' notebooks for this curriculum unit and, thus, were not presented in the table; pyramid, diagram, scribble, tag, scale, and bubble.

Tables, another visual, have been used by students at least once in each school with the exception of School A. The number of occurrences for each type of visual among students within a given school was found to be close. However, the number of occurrences for each type of visual across schools was significantly different. Moreover, with the exception of a few schools, students did seem to have utilised visuals such as concept maps or models which are considered to be important in science learning (see Schools D and G). In addition to this, pyramids, diagrams, scales, tags, or bubbles were not found to have been used in the unit of "Human Reproduction, Growth, and Development".

Table 4. Frequencies of the visual representations in student notebooks for the “Simple Machines” unit

Notebook Code	Table (n)	Graphic (n)	Formula(n)	Drawing (n)	Picture (n)	Box (n)	Highlighter (n)	Star (n)	Flow chart (n)
A2		4	4	35		6		8	
A6			7	47		11		2	
A9			1	11		1		6	
C3			3	44				9	1
C6			4	43					1
C7			4	43		1			
D1			2	17	1			28	
D5			4	35				19	
D9			3	33		2		42	
E1			3	16			4	55	1
E2	1		3	14				7	
E3			3	15				32	1
G1			3	31				1	
G5			5	39		3		5	
G6			5	41		2		4	
F4			2	33		2		7	
F6			2	33					
F10			3	36					
I2			2	75		2		14	
I5			3	86	13	5		12	
I6			3	86		1		1	
K3			4	58				14	
K5			4	26				10	
K6			5	58		5	1	14	
M1			4	27		5		11	
M3			5	39		9		38	
S1			5	36				12	
S2			5	41				26	
S4			5	41				23	
T2			2	90		1		7	1
T4			3	83		2		7	1
T6			3	79		7	40	8	2
Y1			3	46		7		15	
Y2			5	63		3		5	
Z1			2	28				15	
Z2			5	34		2			1
Z3			5	26		1		2	

Note: The following visual representations were not present in any students’ notebooks for this curriculum unit and, thus, were not presented in the table; pyramid, diagram, scribble, model, scale, acronym, tag, bubble and concept map.

The analysis of the kinds and frequency of the visual learning representations used in student notebooks on the unit of “Simple Machines” (see Table 4) reveals that the most frequently used visual representations were drawings which included; student copies of teacher drawings about the course content and the copies of the visuals in the course book. The second most frequently used kind of drawing were stars which were used to highlight important definitions and/ or explanations. It can be understood that those two types of visuals have been used by students in all schools, though, students in a number of schools were found to have utilised those visuals more frequently than other students. The stars used to highlight definitions and/or explanations were not used as frequently in Schools C, A, F, and G when compared to other schools. Findings on other visual representations in Table 4 suggest that graphics were only used by a single student in School A. Likewise pictures were used only by two students in two different schools (School I and D). Additionally, boxes which are used by students to highlight important information were used at least once in all schools with the exception of School E and S. On the other hand, it was found that students did not make any use of pyramids, diagrams, scrabbling, models, scales, acronyms, tags, or bubbles in the "Simple Machines" unit.

Table 5. Frequencies of the visual representations in student notebooks for the "Structure and Characteristics of Matter" unit

Notebook Code	Table (n)	Graphic (n)	Formula(n)	Drawing (n)	Picture (n)	Diagram (n)	Scale (n)	Bubble (n)	Box (n)	Highlighter (n)	Star (n)	Flow chart (n)
A2	4		13				1				6	1
A6	2	2	20	1			1		5		11	1
A9	2	2	21	1			1				25	1
C3	2		21				1				5	2
C6	4		13				1				5	4
C7	3		18				1				5	3
D1				13	4		1				98	
D5	1		7	7	1		1				53	
D9	3		5	9			1	6			54	
E1	2		20	3			1		8	7	30	1
E2	2		15	2			1		6		5	1
E3	1		20	2			1			15	71	1
G1	4		12	8			2				2	
G5	4		12	43			2					
G6	5		13	10			2					
F4	3		24	11		2					24	
F6	4		23	7			1				15	
F10	4		12	12			1					
I2	16		15	5			1		5		80	
I5	15		37	7	1		1		16		44	
I6	20		20	8	1		1		9		24	
K3	3	9	30	7			1				7	1
K5	4	1	23	2			1		2		10	1
K6	7	9	29	5			1		1		28	
M1	5		21	4			1		4		32	2
M3	3	2	14	3			1				44	
S1	6	9	41	13			1				80	
S2	6	10	40	12			1				96	
S4	6	10	40	12			1				85	
T2	4	10	35	6			1			11	51	
T4	5	9	50	5			2		3		56	2
T6	7	10	39	5			1			30	13	
Y1	7		13	4			1				21	
Y2	8		20	9			1				95	
Z1	3		24	4			1				76	1
Z2	2		10	1					5		12	
Z3	3		9	18							32	

Note: The following visual representations were not present in any students' notebooks for this curriculum unit and, thus, were not presented in the table; scribble, model, pyramid, acronym, tag and concept map.

It can be seen in Table 5 that drawings and stars were the most frequently used visual representations in the "Structure and Characteristics of Matter" unit. Stars were used in all schools and drawings were utilized in all schools with the exception of School C. Moreover, students in School C and G did not make as much use of stars as students in other schools. The analysis of findings in Table 5 shows that tables were used by students in all schools and most frequently in School I. Likewise, it was found that students made frequent uses of graphics in Schools K, T, and S; students in School A did not make much use of graphics; and notebooks collected from the remaining schools did not include any samples of graphics.

On the other hand, boxes, used by students to remark important information were frequently used by students in Schools I and E, but were not used by students in other schools. Flow charts were mostly present in student notebooks in School C, but they were infrequent or did not exist at all in notebooks collected from the remaining schools. In addition, pyramids, models, acronyms, tags, bubbles, and concept maps were not used by students in student notes for this unit.

Table 6. Frequencies of the visual representations in student notebooks for the "Light and Sound" unit

Notebook Code	Table (n)	Graphic (n)	Drawing (n)	Picture (n)	Scribble (n)	Acronym (n)	Tag (n)	Bubble (n)	Box (n)	Highlighter (n)	Concept map (n)
A2			6								
A6			11								
A9			8								
C3			8	2							
C6			9	1						2	
C7			8	1							
D1	1		3	2							
D5	1		3								
D9	1		5								
E1			14							5	
E2			14								
E3	1		14							4	
G1	3		13								
G5	3		15						2	3	
G6	3		14								
F4			21								
F6			24								
F10		1	20								
I2	3	2		22			2		2		6
I5	3	2		11							4
I6	3	2		24			2			4	5
K3	2		12								
K5	2		14		1			1			
K6	2		15		1			1			
M1			13								
M3			12								
S1			17								
S2			18			1					
S4			19			1					
T2			31								
T4			23								
T6	1		24						1	6	1
Y1			6								
Y2			8								
Z1			12								
Z2			12								
Z3			13								

Note: The following visual representations were not present in any students' notebooks for this curriculum unit and, thus, were not presented in the table; formula, pyramid, diagram, scales, model, star and flow chart.

The analysis of the visual representations in students' notebooks showed that the most frequently used visual representations in the "Light and Sound" unit was drawing (Table 6). There were plenty of drawings in student notebooks with the exception of School D. Another interesting point was that stars, which were used by students to highlight important definitions and explanations, were not used at all in this unit.

Models, which are considered to be an important visual learning representation, were only used in School I. Moreover, acronym, which is based on coding information, were only used by students in Schools I and S.

concept maps, on the other hand, were only used by students in School T. Bubbles were only used by students in Schools K and I, though infrequently. Formulas, pyramids, diagrams, scales, model, star and flow charts were not used by students in this unit.

Table 7. Frequencies of the visual representations in student notebooks for the "Living Organisms and Energy Relationships" unit

Notebook Code	Table (n)	Graphic (n)	Formula(n)	Drawing (n)	Picture (n)	Pyramid (n)	Box (n)	Highlighter (n)	Star (n)	Concept map (n)	Flow chart (n)
A2		5	2	1		1			6		1
A6		5	1	1		1			4		1
A9		5	2	1		1			2		1
C3		4	2	2		2					1
C6		4	2	2		1					1
C7		4	2	2		1					1
D1			1		3	1					
D5		13	1	3		1			5		1
D9		13	1	3		1			10		1
E1			1	2		1					1
E2			1	2		1					1
E3			1	2		1			4		
G1			2	1		1				1	1
G5						1				1	1
G6			2	1		1	1			1	1
F4		12	2	13		4			11	1	
F6		8	2	2		3				1	
F10		12	2	3		2				1	
I2	1	4	2	9		1	1		8		
I5		4	2	9		1	2		7		
I6		4	2	9		1	1		5		
K3		5	2	8		2			11		2
K5		5	2	8		2	1	2	12		2
K6		5	2	8		2			14	1	2
M1	2	8	2	1		2			16		1
M3	1	7	2	5		1			36		1
S1		5	2	1		2			17	1	1
S2		5	2	1		2			23	1	1
S4		5	2	1		2			20	1	1
T2		6	2	4		3			20	1	
T4		5	2	2		2	2		15		1
T6		5	2	4		2	2		19	1	
Y1			2		4				9		
Y2			2		4						
Z1	2	8	2	1		2			44		1
Z2		4	1								
Z3			2						12		

Note: The following visual representations were not present in any students' notebooks for this curriculum unit and, thus, were not presented in the table; diagram, model, scale, scribble, acronym, bubble and tag.

Table 7 includes the details regarding the kinds and frequency of the visual learning representations in students' notebooks for the "Living Organisms and Energy Relationships" unit and it can be understood from the table that the most frequently used visuals by students were graphics, drawings, and stars. However, graphics were not present in student notebooks collected from Schools E, G, and Y and stars were not present in student notebooks collected from Schools C and G. Additionally, tables were not used by students in Schools I, M, and X and flow charts were, at least, used once by students from all schools but Schools I and F. In addition, diagrams, scribbles, models, scales, acronyms, tags, and bubbles were not present in any of the notebooks collected.

Table 8. Frequencies of the visual representations in student notebooks for the “States of the Matter and Heat” unit

Notebook Code	Table (n)	Graphic (n)	Formula(n)	Drawing (n)	Bubble (n)	Box (n)	Star (n)	Flow chart (n)
A2	3	3	2	1			15	
A6								
A9	3	3		2		6	6	
C3	5	7	2	3		1	1	1
C6	5	7	2	4		2	2	1
C7	5	7	2	4				1
D1	1		1	4			23	
D5	1		1	4		2	14	
D9	1			3		1	20	
E1		2	1	3			11	
E2		2	1	3			9	
E3		2	1	3			15	
G1	3	4	2	8		1	5	1
G5	4	4	2	11		5	6	1
G6	3	3	2	12		1	5	1
F4	1	6	2	13		1		
F6	1	12	2	10			1	
F10	1	13	2	7			11	
I2	6	2	2	20			20	
I5	6	3	2	21		2	33	
I6	7	2	2	21			9	
K3	3	7	2	6	2		21	1
K5	4	7	2	8			20	1
K6	4	7	2	8			23	1
M1	3	7	2	6		3	7	1
M3	2	6	2	6			22	1
S1	1	3	1	7		1	11	1
S2	1	3	1	7		2	10	1
S4	1	3	1	7			11	1
T2	1	14	2	10			1	1
T4	1	19	2	9		2	11	1
T6	1	16	2	10		2	9	1
Y1	2		2	2				
Y2	3		2	2				1
Z1	1		1				2	1
Z2			1					1
Z3			1			1	4	1

Note: The following visual representations were not present in any students’ notebooks for this curriculum unit and, thus, were not presented in the table; picture, pyramid, diagram, scribble, model, scale, acronym, tag, highlighter and concept map.

The details provided in table 8 show that drawings and stars were the most frequently used visual learning representations by students in the “Structure of the Matter and Heat” unit. One exception was School X where students did not seem to utilize drawings in this unit. Additionally, tables were mostly used by schools with the exception of School E and students in a number of schools (see School C and I) made more frequent uses of tables in comparison to other schools. Graphics were also frequently used by students with the exceptions of Schools X and Y. Moreover there were schools where students’ use of graphics was between two to three times higher than other schools (see Schools F and T). On the other hand, flow charts were not used by students in almost half of the schools. Moreover, it was found that one of the students in School A did not have any notes whatsoever on this unit (see Student A6). In addition, pictures, pyramids, diagrams, scribbles, models, scales, acronyms, tags, highlighters and concept map were not used at all by students in this unit.

Table 9. Frequencies of the visual representations in student notebooks for the "Electricity in Our Lives" unit

Notebook Code	Drawing (n)	Picture (n)	Acronym (n)	Highlighter (n)	Star (n)	Flow chart (n)
A2	14				6	
A6	11				2	
A9	15				2	
C3	10					
C6	10					
C7	6					
D1	6	9			25	1
D5	25				16	1
D9	12				9	1
E1	9				3	
E2	9				3	
E3	9				3	
G1	6				4	
G5	41			1	7	
G6	12				2	
F4	17					
F6	17					
F10	23					
I2	33				11	1
I5	58				16	1
I6	62				4	1
K3	28				5	
K5	29				3	
K6	28				5	
M1	22		1		9	
M3	20		1		10	
S1	19				23	
S2	20				21	
S4	21				22	
T2	18					1
T4	17				12	1
T6	17				1	1
Y1						
Y2	26					
Z1						
Z2	5				7	
Z3	6				18	

Note: The following visual representations were not present in any students' notebooks for this curriculum unit and, thus, were not presented in the table; table, graphic, formula, pyramid, diagram, scribble, model, scale, tag, bubble, box and concept map.

The most frequently used visuals in the "Electricity in Our Lives" unit were drawings and stars (see Table 9). With the exception of Schools C and F, students frequently made use of stars to highlight important definitions and descriptions. In addition, one student from School Z and another from School Y did not have any notes or visuals in their notebooks. Since the unit included topics from Physics, it was interesting to observe that none of the notebooks included formulas or graphics and tables were only used once. Additionally, flow charts were only used in Schools I, D, and T. On the other hand, students did not make any use of table, graphic, formula, pyramids, diagrams, scribbles, models, scales, tags, bubbles, box or concept maps.

Table 10. Frequencies of the visual representations in student notebooks for the "Earthquakes and Weather Conditions" unit

Notebook Code	Table (n)	Picture (n)	Star (n)	Flow chart (n)
C3		4		
C6		4		
C7		3		
D1		8	5	
D5		6	7	
D9		4	4	
K3	1			1
K5	1			1
K6	1			1

Note: The following visual representations were not present in any students' notebooks for this curriculum unit and, thus, were not presented in the table; graphic, formula, drawing, pyramid, diagram, scribble, model, acronym, scale, box, highlighter, tag, bubble, no and concept map. Besides, for any notes or visuals did not have for this unit in student's notebooks in Schools A, E, G, F, I, M, S, T, Y and Z, those has not showed in table.

The analysis of the visual learning representations for the "Earthquakes and Weather Conditions" unit showed that most students did not have any notes or visuals for this unit in their notebooks (see Table 10). The only exceptions were the notebooks collected from Schools C, D, K and Z. Only notebooks collected from students in Schools C and D included pictures. Tables and flow charts were only used once by students in School K. Additionally, stars, used to highlight important definitions and descriptions, were only used in School D and tables were only used once in notebooks collected from students in this school.

Discussion and Conclusion

This study aimed to investigate 8th grade students' science notebooks at the end of the academic year in order to identify the kinds and frequencies of the visual representations used by students. For this purpose, a total of 93 (37 of which were randomly selected for analysis) 8th grade students' science notebooks were collected from 13 schools located in the city centre of Kars, Turkey. There were three main findings. First of all, it was observed that the visual representations within students' notebooks were grouped under two main codes across schools as well as the units of the curriculum. One of those codes was drawing which represented students' copies of the visuals that have been drawn by their teachers on the board or the visuals that have been included in the science books. The other main code was star which was used by students to highlight important definitions and explanations provided by teachers. Drawings are one of the most effective visual representations that can be used to develop students' conceptual understanding in science (Stern et al., 2003). On the other hand, Coleman, McTigue and Smolkin (2011) found that, in science subjects, students did not prefer visuals which included drawings. They explained that students did not prefer the drawing visual because of teachers' approach or their lack of awareness about the importance of the drawings. Similarly, Henderson (1999) pointed out that teachers generally avoided the use of drawings because they had difficulties in explaining scientific content through drawings. Chapman (2005) defined drawing as using art in science and found that only 10 % of secondary school teachers were interested in using drawings in their classes. Our study, on the other hand, showed that drawings were frequently used across the units of the curriculum and the schools from which the notebooks were collected. In the present study, it is possible to relate students' frequent use of drawings to those visuals' relative ease of use. Moreover, star, the second most frequently used visual representation, was used by students to highlight important definitions and explanations provided by teachers. Ruiz-Primo, Li, Ayala and Shavelson (2004) noted that if students do not question the importance of the information that they record in their notebooks, then, notebooks would lose their advantage as a learning tool that provides information regarding students' performance. In general, signs similar to stars are used in Turkish students' notebooks for two reasons. The first of those reasons is to highlight the ideas that students consider to be important and the second is for the teacher to mark students' homework as a sign that they did their homework. The present study, on the other hand, revealed that stars were not used for second purpose, but rather to highlight the content that is considered important by students. Most studies indicate that teacher feedback is necessary for students' performance in their notebooks and that those signs should be observable in student notebooks. Such feedback is considered to be significant in encouraging students to develop their scientific communication skills (Ruiz-

Primo, Li, Ayala, & Shavelson, 2000; Ruiz-Primo, Li & Shavelson, 2001; Ruiz-Primo & Li, 2004; Ruiz-Primo & Li, 2013).

The second main finding in this study was that diagrams, models, concept maps, and pictures, which are considered to be very effective in developing student understanding, were made little use of by students or were not used at all across the curriculum units as well as the schools from which the notebooks were collected. On the other hand, graphics and tables were used more frequently than those visual learning tools. On her extensive review of literature investigating the use of diagrams between 2002 and 2014, Tippett (2016) found that diagrams made significant contributions to facilitate the comprehension of scientific concepts. Therefore, the conclusion reached at the end of analysing the collected notebooks- which suggest that students made very little use of diagrams- can be interpreted as an important drawback in supporting students' science understanding. There could be different reasons for the lack of diagram use: a) teachers might have not been successful in relating that visual representation with the course content and b) teachers might not have been aware of the effectiveness of diagrams in communicating scientific knowledge. Research studies corroborate the idea that the use of such visuals facilitates the teaching of complicated science content by summarizing it through pictures and conceptual tags (Amare & Manning, 2007; Cromley et al., 2013; Gilbert, 2005; Gilbert, 2010; Gilbert & Treagust, 2009; Tippett, 2016; Waldrip & Prain, 2012; Waldrip, Prain & Carolan, 2010). Additionally, it has been observed that the use models were limited among students. However, models are considered as an important visual representation in science teaching (Gilbert, 2010; Harrison & Treagust, 2000). This is because models schematise the characteristics of science topics and facilitate the structuring and communication of scientific knowledge. Therefore, it is possible to argue that teachers of the students whose notebooks have been collected might have been ineffective in supporting students to develop perspectives of creating their own models. Furthermore, another interesting finding was the fact that concept maps were only used in two instances. Concept maps are visuals that summarize the organization of information about a certain topic (Novak & Cañas, 2008). Zwaal and Otting (2012) have defined concept maps as valuable visual learning tools that support the solution of problems, develop conceptual understanding, and remember information. Thus, it can be understood that the potential benefits of concept maps have been ignored during classes in the schools where the notebooks have been collected from. The reason for this finding might be that teachers did not consider themselves as sufficient enough to prepare such tools or considered the process of preparing such tools as a challenging one.

Similarly, the use of graphs was not frequent among students whose science notebooks were collected. The notebooks included graphs only in four units across four schools. Moline (1995) defined graphics as a visual learning tool used to present measurement results relating to specific data. The use of graphs can contribute to students' questioning and knowledge structuring skills in certain topics (i.e. heat and temperature). The results in the present study suggested that the use of graphs among schools inadequate. Therefore, it can be interpreted that the science teachers in those schools were not successful in integrating graphics into teaching processes (i.e. providing explanations, interpreting graphs) regarding measurements. Tables, another visual representation, were frequently used in four units of the curriculum and at close frequencies across the schools. In their study conducted with 388 science teachers in the US, Coleman, McTigue and Smolkin (2011) found that the most frequently used visual representations by teachers were tables in science instruction. Moline (1995) defines tables as a two-dimensional visual learning tool that allows the structuring of knowledge by connecting information. The most basic characteristic of this visual learning tool is that it summarizes knowledge, thereby, facilitating the understanding and structuring of complicated science knowledge. It can be interpreted, that the use of tables across schools as well as curriculum units was not sufficient.

The third main finding of the study was that there were differences between the numbers of visuals used across the same unit of the curriculum in student notebooks collected from the same school. For example, in School A, there was almost a five times difference between students' use of tables in the unit for "Structure and Characteristics of Matter" (see Table 5). Additionally, it has been found that students did not include any visuals in certain units (especially the last unit "Earthquakes and Weather Conditions). The most probable explanation to this could be that the teachers did not cover or did not have enough time to cover that unit. The fact that all of the randomly selected notebooks from the same school did not include any content on that unit can be considered as evidence supporting that claim. Moreover, the availability of visual representations for the same unit in notebooks collected from other schools can be considered as another proof supporting that claim. Another finding regarding the unavailability of content in certain units in student notebooks is the fact that notebooks selected from the same school did not include any visual or text data. In order to correctly identify the reason for such an incident, details regarding those students' attendance and the conditions of teaching should be gathered. An important point of consideration is that both teachers and families seemed to lack in terms of keeping track of science subjects that students were not able to complete. Thus, it is possible that students would experience difficulties in understanding and structuring new knowledge in the future because of their lack of learning in the 8th grade.

Recommendations

The results of the present study suggest that science teachers selected for this study are insufficient in guiding students to use visual learning representation in order to make their learning more efficient. Therefore, it is clear that they need further professional development opportunities with regards to this aspect. Unfortunately, it has been observed that visual learning representations are not used frequent enough to develop science understanding of the students studying in schools where the notebooks were collected from. The present day main approach to develop students' science understanding does not support the idea of students copying knowledge from the books or the teacher, but rather learning it through questioning and evaluation. And, in addition to writing, it is important to include different visual learning tools (i.e. models, diagrams, tables, and graphics) into that process. The most important point that should be highlighted in this respect is that teachers should guide students in how to take and record notes in their notebooks (Nesbit, Hargrove, Harrelson & Maxey, 2004). Whilst shaping students' understanding of science concepts, teachers should provide students with opportunities to use visual representations (i.e. models, drawings, shapes, pictures, and diagrams) in addition to writing and also create opportunities for students to question their thinking. Additionally, science teachers should closely follow their students whilst taking notes into their notebooks and use those notebooks as assessment tools on an ongoing basis. NGSS (2013) highlight the importance of visual literacy for secondary school students to structure complicated knowledge. Therefore, science teachers should provide their students with opportunities to develop their visual literacy. One of the most important things that teachers could do to support their students' development of visual literacy is to include various visual learning activities for different units/topics in their classes. Eventually, student notebooks provide important clues regarding within and out of class teaching practices experienced by students as well as the profiles of the teachers.

The following conclusions have been based on the findings; teachers should intensively review the notebooks of their students at the end of each unit and contribute to their students' development of science understanding. Additionally, in-service training opportunities can be organized for teachers on how notebooks should be used in the teaching of specific science subjects. In this sense, guidance books specifically designed on how student notebooks should be used in science subjects (NSTA, 2008) and examples should be used to support teachers. Another suggestion is to integrate additional courses on, for example, how to use visuals and how to use student notebooks into science teacher preparation programs. Such courses should include observations of how student notebooks are used in real classes as well as provide opportunities to analyse such notebooks. Last but not least, the current situation should be analysed from the perspective of teachers and students through a more focused (i.e. focusing on just one unit of the curriculum) and/or much bigger sample size and different region.

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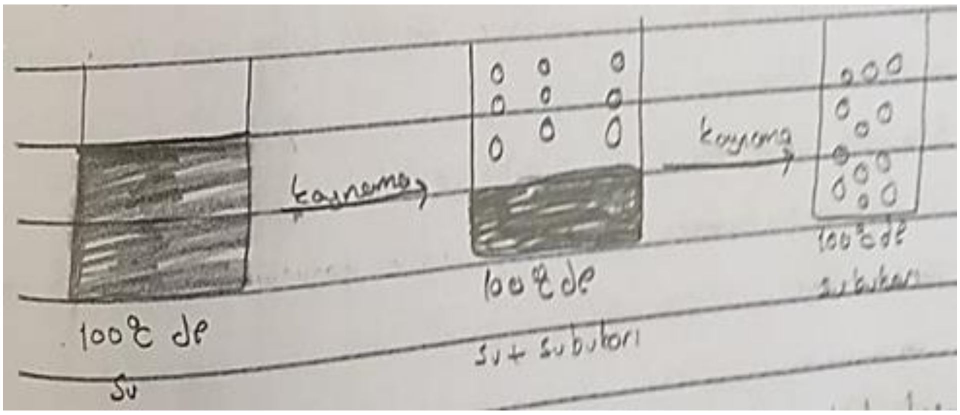
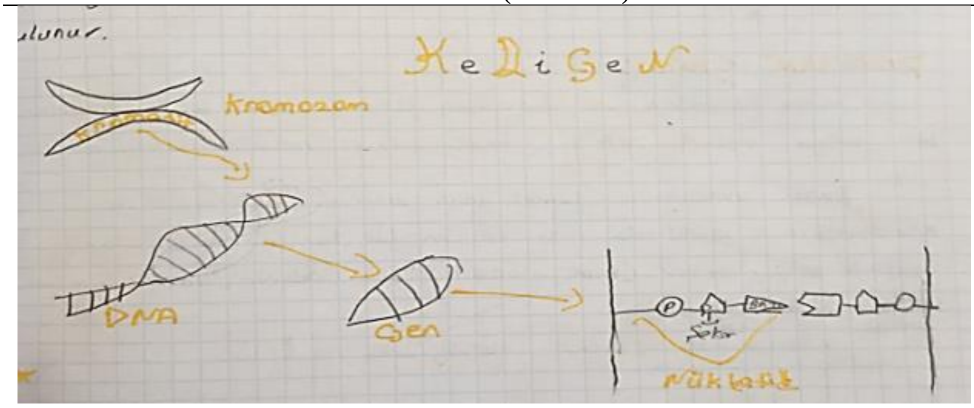
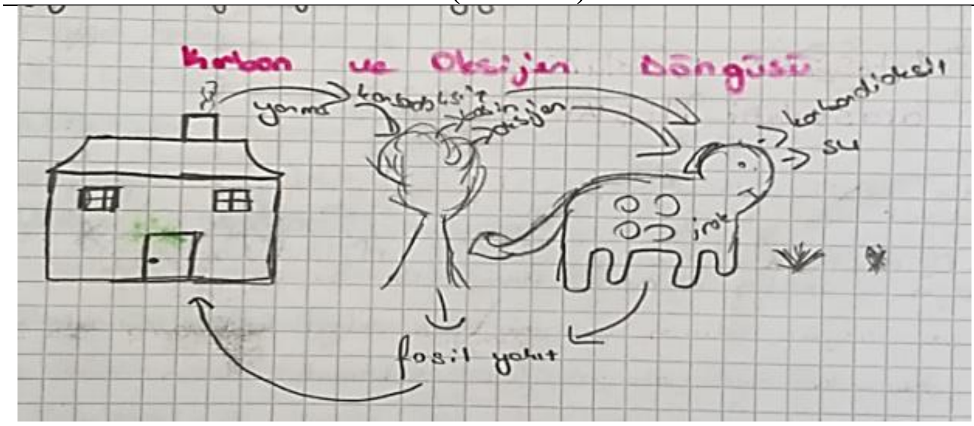
Appendices

Appendix A. The picture of all collected student notebooks

Appendix B. The picture of notebooks randomly selected for analysis

An Example Visual Representation	Code
 An example of drawing for the States of the Matter and Heat unit (Student I5).	Drawing
 An example of acrostic for the DNA and Genetic Code unit (Student S4)	Acronym
 An example of flow diagram for the Transformation of Energy and Ecology unit (Student K6)	Diagram

Appendix C. Coding Example of Visual Representation

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MUBEM & SAC: STEM Based Science and Nature Camp

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Abstract

The idea behind the MUBEM & SAC: STEM based science and nature camp was a transformation of scientific knowledge into artifacts using the engineering design process and scientific inquiry. The goals of the camp were developing an integrative science perspective in accordance with the nature of STEM education, supporting career choices of participants for STEM fields, experiencing outdoor learning environments and researches with real scientists, internalizing engineering design process by creating artifacts, and comprehending interaction with nature and science. The participants were sixth and seventh grades gifted students (Male: 14 and Female: 15). STEM attitude scale, researcher notes, artifact, camp, and activity evaluation forms were used as data collection tools. The several disciplines such as astronomy, archeology, music, and mathematics involved the camp. The participants found the opportunity to use telescopes, experience an extensive archaeological excavation, observe the near-nano size object with electron microscopes, construct a bridge like an engineer, and design artifacts like rockets and holograms during the camp. According to results, the science and nature camp supported participants' STEM attitudes and participants' views on the science and nature camp were positive. In addition, participants' artifacts were also qualified as STEM artifacts.

Introduction

Learning about STEM (Science, Technology, Engineering, and Mathematics) has evolved in the past decade. Nowadays, young learners have opportunities to reach the variety of knowledge resources such as science centers, STEM clubs, after-school activities, museums, online activities, and science and nature camps (National Research Council [NRC], 2015). These informal learning environments are particularly beneficial in creating excitement, interest, and motivation to learn about the natural world. They can enable students thinking themselves as science learners who engage with science and sometimes produce scientific knowledge (Bell, Lewenstein, Shouse, and Feder, 2009). Especially, gifted students' education requires differentiated learning experiences about STEM (Lundgren, Laugen, Lindeman, Shapiro, and Thomas, 2011). The MUBEM & SAC: STEM Based Science and Nature Camp is an effort to provide gifted students (sixth and seventh grades) with an out-of-school summer activity which the participants could engage with STEM fields. The Science and Nature Camp's goals were, through scientific inquiry, to expose gifted students to a variety of STEM disciplines, to experience STEM researches with the scientists, and to increase participants' attitudes in STEM fields.

STEM Education for Gifted Students

The needs of societies have changed due to the growing technology and global economic competition. Therefore, rising future inventors, innovators, scientists, and engineers is one of the main issues of educational systems all around the world. The concern about the low number of future professionals to fill STEM jobs and careers has been increased the need for STEM education (van Langen and Dekkers, 2005). This workforce who is equipped with 21st-century skills such as critical thinking, creativity, and productivity can create sustainable economic development (Ananiadou and Claro, 2009). *Rising above the Gathering Storm Report* recommends two main action plans to cope with these global challenges; increasing gifted and talented students pool by improving K–12 STEM education, and identifying and developing the best students (National Academy of Sciences [NAS], National Academy of Engineering [NAE], & Institute of Medicine [IM], 2007). However, as Jolly (2009) mentioned, the gifted and talented population has great potential for future STEM pioneers; this population is still a resource that is not implicitly utilized.

* This article is presented as an oral presentation at International Conference on Education in Mathematics, Science & Technology (ICEMST) which is held in Marmaris between April 28th and May 1st, 2018.

Identification of gifted students does not have commonly accepted criteria. Therefore, gifted, highly able, exceptionally able or talented are commonly used terms to express giftedness (Maltby, 1984). According to United States Department of Education [USDE] (1993), gifted and talented students are defined as children and youths who demonstrate high-performance capability in intellectual, creative and/or artistic areas, possess an unusual leadership capacity, or excel in specific academic fields. Renzulli and Reis (1985) emphasize three areas to identify giftedness such as above average ability, high levels of commitment to tasks, and high levels of creativity. National Association for Gifted Children [NAGC] (2010) proposes a structured area of activity to identify giftedness. The gifted students are those who present outstanding levels of aptitude or competence in one or more domains such as a structured area of activity with its own symbol system (e.g., mathematics, music, and language) and/or set of sensor motor skills (e.g., painting, dance, and sport). In Turkey, identifying gifted students depends basically on the traditional Wechsler Intelligence Scale for Children (WISC-R) test (Tarhan and Kılıç, 2014). The common characteristic of these definitions is that the individual exhibits or has the potential to demonstrate extraordinary performance in a specific domain.

As an institutional out of school program, SACs (Science and Art Centers) serve a very large majority of the identified gifted students in Turkey. The aim of the SACs is fostering primary, middle, and high school's gifted students' scientific thinking abilities, creativity, productivity, problem-solving ability and social, and aesthetic values. SACs comprise five-stage program; orientation, assistance training, individual skills awareness, special skills development, and project production/management. SACs focus mainly on project and problem-based learning, individually or small group works in the educational process (MNE, 2007). However, SACs do not have a special curriculum for STEM education; they have begun paying attention to STEM education in recent years. In a similar way, several types of educational programs are used for gifted education in the context of STEM such as selective schools, full-time separate classes, distance education, and summer enrichment programs (Olszewski-Kubilius, 2010).

It is advantageous that different options are provided to the gifted students but the main point to be focused is quality of STEM education, particularly disciplinary integration (President's Council of Advisors on Science and Technology [PCAST], 2010). Wang, Moore, Roehrig, and Park (2011) state that teachers who teach different subjects can have different thoughts about effective STEM integration. This situation leads to occur different level implementation of STEM integration such as multi-disciplinary, interdisciplinary, and transdisciplinary. Myers and Berkowicz (2015) describe STEM as a philosophy of teaching and learning that removes borders of the traditional single-discipline courses and demands cross-pollination of several disciplines leading to transdisciplinary levels of integration. The transdisciplinary perspective replaces disciplinary, multi-disciplinary and interdisciplinary practices and is better meet to complex and open-ended problems. This perspective goes beyond separate or interdisciplinary knowledge and applies domain particular knowledge in an integrated framework (Back, Greenhalgh-Spencer, and Frias, 2015). In addition to this, according to the National Research Council [NRC] (2011) effective STEM education should emphasize;

- to capitalize on students' early interest and experiences,
- to identify and build on what student already knew,
- to provide students with experiences to engage them in the practices of science,
- to sustain students' interest.

In this way, the students actively engage STEM, deepen their understanding of basic ideas in STEM and concepts that are shared across areas of STEM. Students also engage with fundamental questions about the designed and natural worlds, and gain experience as scientists have investigated those questions (NRC, 2011). According to Bybee (2010), true STEM education should increase students' understanding of how products work and support the usage of technologies. STEM education should also comprise an engineering design process because engineering is directly related to problem-solving and innovation. It is essential for the effective STEM pedagogical practices that teaching approaches are transformed from traditional, teacher-centered pedagogies to active, student-centered pedagogies to support learning (Kennedy and Odell, 2014). One of the pedagogical practices that have been shown to be effective in promoting student engagement and achievement in STEM disciplines is inquiry-based learning (McDonald, 2016). Inquiry-based learning involves students learning through their own cognitive and physical activities starting with students' current ideas. Students gather evidence, analyze and interpret data to develop more powerful and scientific ideas to explain new events or phenomena. Students, like scientists, develop a sense of appreciation for the nature of learning and scientific activities by working on scientific questions. In addition, inquiry-based learning has an important role in helping students improve their meaningful understanding (Harlen, 2015). Inquiry-based learning environments can be organized to effective STEM learning for gifted students. In this case, gifted students should engage the activities as active investigators (Taber, 2010). Taken together, we used this background promoting a summer science and nature camp as an enriched informal learning environment to improve STEM education for gifted students.

Science and Nature Camps as an Informal STEM Learning Environment

People learn when they interact with their environments. The huge amount of information is obtained from family and peers through individual interactions (Salmi, 2003). Most children spend a limited time in school. Apart from school time, children engage in several activities such as watching movies, playing games, using social media, participating in sports, reading magazines and newspapers, or having a conversation with friends. Furthermore, children can learn via museums, science centers, and out-of-school time (OST) programs which are provided widely by organizations, educational networks, and state-funded programs (NRC, 2015). Majority of these settings are described as informal learning environments. Informal learning environments may have considerable influence on what children learn (Gerber, Cavallo, and Marek, 2001). Particularly, OST programs such as science and nature camps are increasingly viewed as both complementary and supplemental to school learning (Pierce, Bolt, and Vandell, 2010).

Informal learning has often considered as the opposite of formal learning. However, there is no certain consensus in the literature regarding the definition of informal learning (Salmi, 1993). The major problems about the distinguishing informal learning from formal learning are the fact that informal learning can occur within formal settings and differences caused by school systems (Hofstein and Rosenfeld, 1996). Sullenger (2006) defines informal learning as settings outside the classroom where learning occurs. According to Crane, Nicholson, Chen, and Bitgood (1994), informal learning refers to activities that occur outside the school environment, are not developed mainly for school and curriculum, and include voluntary participation. United Nations Educational, Scientific and Cultural Organization [UNESCO] (2012) states that informal learning is a form of learning that non-institutionalized, less organized and less structured than either formal or non-formal education, but it can be intentional or deliberate. These three definitions have different or opposite features, but their common point is emphasizing learning outside the classroom. However, some learning environments such as virtual reality and augmented reality can be part of learning without the need for school or a physical environment (Salmi, Kallunki, and Kaasinen, 2012). Hawkey (2002) and Salmi (2010) state four discrete cells model to categorize the boundaries of real, virtual, formal, and informal learning environments (See Figure 1).

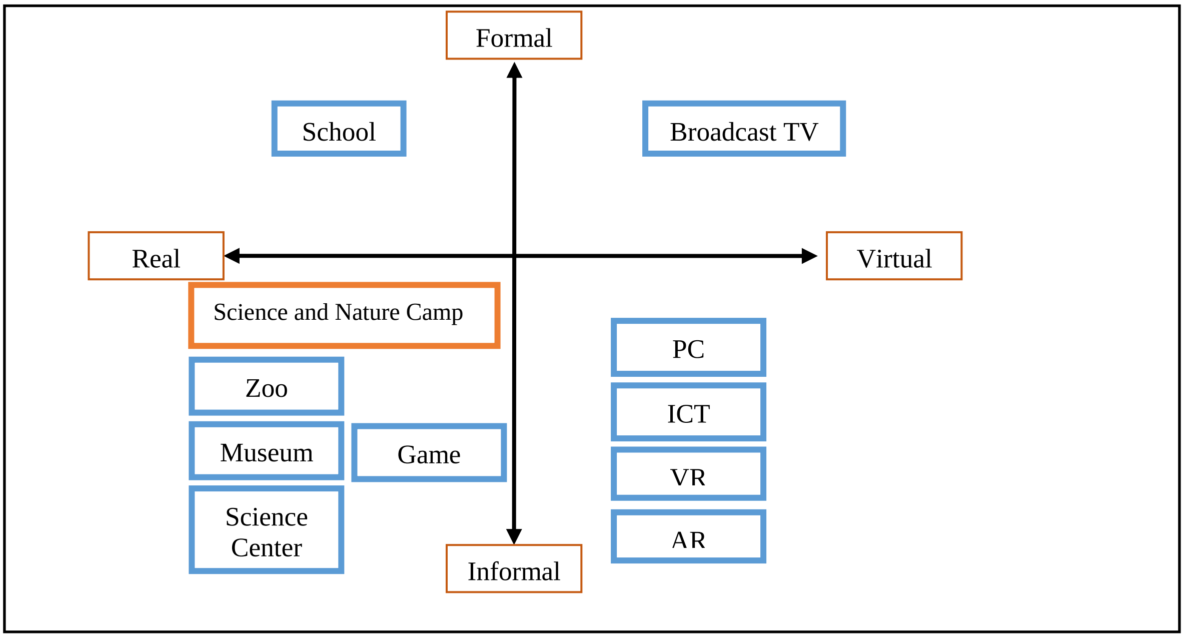

Figure 1. Persistent dichotomies or blurring boundaries? (Adopted from Hawkey, 2002; Salmi, 2010)

As an OST program, science and nature camps are located in the real environment and near the boundary line between formal and informal education. Because the science and nature camps are held away from classroom environments such as nature or national parks. These camps have specific educational tasks given by teachers. In this context, this type of design is highly influential in closing the gap between formal and informal learning (Salmi, Kallunki, and Kaasinen, 2012).

Science and nature camps, in the context of STEM education, are helpful for giving inspiration to students through hands-on and experience-based activities. Supporting students in this scope, some particular activates are proposed such as providing to access unique scientific instruments to enhance students' excitement about the STEM fields, and meeting with practicing scientists to change students' preconceived ideas about scientific careers (Parliamentary Office of Science and Technology [POST], 2011). Concordantly, science and nature camps give students the opportunity to experience situations that they have not experienced in formal education settings. These experiences directly affect students' formal STEM learning (NRC, 2015).

According to POST (2011), these kinds of informal STEM initiatives aim to help students as the following features;

- to improve attitudes to STEM,
- to change biased ideas about scientists and scientific careers,
- to improve behavior,
- to allow understanding of how science works,
- to improve knowledge of STEM.

Different and enriched learning designs and environments can be created to achieve these goals. In this context, STEM education practices which conduct in nature can offer a unique experience to students. Students who participate in STEM practices outside of the school develop positive dispositions toward STEM and create social settings that promote lifelong learning (Dailey, Cotabish, and Jackson, 2018). Learning outside of ordinary learning environments, especially in nature, can revive students' sense of curiosity and discovery. STEM education, in nature, effectively connects science, mathematics, social sciences, and art (National Wildlife Federation [NWF], 2015). This integrated approach supports specific skills such as creativity, production, research, design, and holistic understanding of disciplines that are inherent in STEM education.

The aim of this paper is examining the features of a STEM camp for gifted students through project deliverables and learning outcomes. This paper contributes to our understanding of how the project team organizes the camp for gifted students and what activities are involved. MUBEM & SAC: STEM-Based Science Nature Camp is, particularly in Turkey, one of the informal STEM learning environments for gifted students. The Camp is funded by The Scientific and Technological Research Council of Turkey, which is the leading agency supporting the camps under the project call. In the paper, the project deliverables and learning outcomes are examined in the following aspects;

- Participants' attitudes towards STEM fields and 21st-century skills during the camp,
- Participants' evaluations on the camp and the activities,
- Observation notes about the activities,
- Assessments of participants' artifacts.

Method

Science nature camp utilized an embedded mixed methods research design in order to examine the project deliverables and learning outcomes. The description of the camp, participants, project team, learning environment, camp activities, instrumentation, and data analysis are given respectively.

Description of the Camp

MUBEM & SAC: STEM Based Science Nature Camp was held by an application and research center for science education and science and art center to support gifted students with out of school programs. The camp was organized as a one-week program with participants' accommodation. The basic aims of the science and nature camp were;

- to develop an integrative science perspective in accordance with the nature of STEM education,
- to support participants' career choices for STEM disciplines,
- to experience outdoor learning environments and scientific researches with scientists,
- to internalize engineering design process by learning to develop and explore strategies to create

artifacts,
- to discover the interaction of nature and science,
- to comprehend the value of universities for the development of science and culture.

In this context, the participants;

- conducted planned and prepared inquiry-based STEM activities with experts,
- designed scientific knowledge-based artifacts as an individual or group,
- experienced the contribution of universities to science and culture in the local region with technical visits,
- organized a science fair with created artifacts during the camp.

During 7-day, the participants were engaged in observations, experiments, hands-on and minds-on activities, technical visits, engineering design process based activities, artifact-focused workshops, and organized a science fair. A great variety of disciplines, mathematics, physics, archeology, astronomy, engineering, coding, chemistry, biology, zoology, botany, ecology, painting, music, nanotechnology, material engineering, digital technology, and marine biology were involved the science nature camp. The camp program was developed to comprise the conceptual framework of the nature of science, history of science, and scientific literacy, as well as the integration of these disciplines. It was ensured that participants had fun while learning the whole scientific and engineering processes such as developing research questions, creating design and prototype, collecting and interpreting data, and presenting their research conclusions and artifacts.

Participants

MUBEM & SAC: STEM Based Science Nature Camp was open to all sixth and seventh grades gifted students who attended Science and Art Centers all around Turkey. In order to recruit participants, official invitations and project website address was sent out all Science and Art Centers. More than 200 out of a total of 5719 students applied from 106 Science and Art Centers. All of the applicants filed a form that specifies personal information and participation purposes. Three external referees evaluated the applications according to criteria such as never attending a science and nature camp and living in different socio-economic regions in Turkey. Finally, total 29 (n = 15 female and n = 14 male) students recruited as participants for the science and nature camp.

Project Team

MUBEM & SAC: STEM Based Science Nature Camp team had nineteen staff: seven women and twelve men, sixteen facilitators, and three counselors. There were twelve PhDs, two doctorate student, and two teachers among the facilitators. The expertise of facilitators is inquiry-based science education, physics education, astronomy education, chemistry, music, art, biology, marine science, archeology, technology, material and aquaculture engineering. Facilitators had six to forty years teaching and research experiences and at least one nature and science camp experiences. They had responsibilities for organizing activities and helping the nature and science camp to run smoothly. The counselors were accompanied and assisted participants during the activities and throughout all aspects of their day.

Learning Environments

The main location of the science and nature camp is a special camping area in Akyaka district of Muğla Province in southwestern Turkey. Akyaka is a unique place with its history and location. As a part of Caria region, known history of Akyaka reached out to BC 2600. Caria region hosted the Milesian school in Miletus where is an ancient Greek city. The Milesian school played a key role in the history of science (Guthrie, 1962). One of the scholars of the Milesian school was Thales who is recognized for a precursor of modern western science (O'Grady, 2016). He used to explain the world around the universe and us on logos instead of mythos. This area is a very suitable learning environment for STEM education in terms of inspiration for gifted students because it hosted scholar who made a breakthrough in the history of science. In addition to that Akyaka is located at a central point. It is very close to Sedir Island and Mugla Sitki Kocman University. Sedir Island is the area of an ancient Roman resort town with an enormous amphitheater, old city wall, and Cleopatra beach. Some archeology and biology activities conducted in Sedir Island because of its unique sand and endemic flora and fauna. Mugla Sitki Kocman University was another learning environment of the science and nature camp. It has

Moulage museum (includes moulages of Zeus and Alexander the great a prehistoric wall paintings), research laboratories center (includes electron microscopes) natural life park (includes endemic animal species), and aquatic museum (includes one of the most variety and rare aquatic species). These environments are highly contributing to the discovery of the scientific and cultural contribution of the universities for gifted students.

Activities

The activities supported participants with both cognitive (minds-on) and physical (hands-on) activities through scientific inquiry. Basically, inquiry starts with learners' existing ideas and it continues with data collection, data analyze, and evidence interpretation. This process led learners to develop more powerful and scientific ideas to explain new situations (Harlen, 2015). This process is similar to scientific methods and process. Therefore, learners who are engaged in inquiry work as scientists. In this context, scientific inquiry accepted to provoke STEM education by the project team. To support STEM education, the activities of the camp reflected the ideas on scientific inquiry. Additionally, some activities aimed to create artifacts by using engineering design process. We used 5 steps engineering design process suggested by Tayal (2013). These steps were ask, imagine, plan, create, and improve. The activities of the camp are presented below:

1st Day: On the first day of camp, the students engaged the areas of math, science education, and astronomy. They performed mathematical designs with origami and experienced artifact-oriented works with their peers. With "Designs in the Light of the History: From Invisible Steam to Magnetic Field" activity; students get to know about the Industrial Revolution. They took a step to engineering and experienced construction of an electric motor from the magnetic field in the basis of the history of science process. Therefore, they discovered the process of turning scientific knowledge into artifact using the engineering design process. In the evening, for the purpose of experiencing the out-of-school learning environments that form the basis of STEM education, they met the sky in the atmosphere of Akyaka campsite and performed the first sky observation of the camp (see Figure 2).

Figure 2. First day activities of the science and nature camp

2nd Day: To support participants' career choices for the STEM areas, students engaged astronomy and archeology. With the “My Eyes are Always on Sky” activity, students learned developing strategies to create an artifact and discovering. Using advanced technological tools (telescope), they discovered the scientific knowledge underlying these tools. In addition, they created their own artifacts working with their peers. "The Nature of Science: Archeology" activity followed by "the Typical Day for a Scientist: From Mythology to Archeology" activity, they had a holistic point of view towards science by comprehending the relationship between STEM and social sciences. In the evening, with the activity “Astronomy I", they experienced the using of advanced technological tools and made sky observations with their own handmade telescopes (see Figure 3).

Figure 3. Second day activities of the science and nature camp

*3rd Day:*Students experienced History of Science, Biology, Physics, Technology, Engineering, and Astronomy in order to support career choices for STEM areas, which is one of the main objectives of the camp. They comprehend the interaction between nature and science, the advantages that nature bring into society, and how society reflects those advantages in the development of science, by understanding the history of the region. Moreover, they carried out the activities on the Kedriai antique city (Sedir Island) in order to support the learning out of school. In the nature, they found an opportunity to discover endemic flora, fauna, and the special sand of the ancient city of Kedriai by carrying out experiments and observations. When they returned to the campsite in the evening, they created their own design artifacts (holograms) with 'Bring Cosmos into the Classroom: 3D Hologram' activity (see Figure 4).

Figure 4. Third day activities of the science and nature camp

4th Day: Students worked in the areas of Engineering, Architecture, Physics and Art, and Astronomy STEM to support career choices for STEM areas. They carried out "The First Step in the Engineering: A Bridge Design" activity that they internalized the engineering design process and created artifacts with their peers. They evaluated the bridges with engineering perspectives, which involves maximum durability, minimum cost, material usage, and aesthetic aspects. Then they talked over scientists and their scientific research in different points of view with the activity on physics and colors in art. In the evening, they brought their astronomy knowledge and experience to a higher level with "Astronomy III" activity (see Figure 5).

Figure 5. Fourth day activities of the science and nature camp

*5th Day:*Students came together with experts from Art, History, Biology, Materials Engineering, Physics, Atomic Research, and Water Creatures and Information Technologies in their career choices for STEM fields. They had the opportunity of closely observing the laboratories and scientific equipment (scanning tunnel microscope) used by a scientist working in nano sizes in basic sciences and meeting with the scientist and his team. They found the answers to questions they were curious about. On the other hand, they visited the laboratories and collections with the scientists working the underwater creatures. Apart from that, accompanied with experts, they visited Turkey's first indoor moulage museum, Mugla Sıtkı Kocman University Moulage Museum in order to recognize the cultural heritage that the university tries to bring the local people in their university. On the evening of the fifth day, an activity on a holistic point of view towards science and thinking outside of the box is carried out with the students (see Figure 6).

Figure 6. Fifth day activities of the science and nature camp

6th Day: This day, in the careers for STEM fields, students involved in Nano-Technology studies, Information and Coding, and Mathematics. They started the day with a design activity that they implemented on Nano-Fabrics in the field of Nano-Technology so that they internalized the engineering design process. They carried out the activity regarding coding and developing a robot (makey kit) in order to work artifact-oriented way with peers, to develop strategies to create artifacts and to learn discover. They experienced writing commands and some basic mathematical codes. In addition to this, they created the required spare parts in their designs with a 3D printer. In the evening, they prepared for the science fest with the project team (see Figure 7).

Figure 7. Sixth day activities of the science and nature camp

7th Day: Participants organized the Science Fair, one of the out of school learning environments that is a basis of the STEM education. Because 7th day corresponded the weekend time, participants had the opportunity to share their works with the people of the region (see Figure 8).

Figure 8. Seventh day activities of the science and nature camp

Instrumentation

In this paper, the camp project deliverables and learning outcomes are examined via qualitative and quantitative instruments. The instruments included STEM attitude scale for participants, camp and activity evaluation forms for participants, researcher notes, and participants' artifact evaluation forms.

STEM attitude scale developed by Faber, Unfried, Wiebe, Corn, Townsend, and Collins (2013) and adopted in Turkish by Yildirim and Selvi (2015). STEM attitude scale has a total of 37 items instrument based on a five point Likert scale, ranging from certainly agrees to certainly disagree. The attitude scale administered to gain an understanding of the effect of the camp on students' attitude STEM fields and 21st-century Skills. Example scale statements included: I would consider a career in science, I am the type of student to do well in math, and I am confident I can include others' perspectives when making decisions. Four dimensions of the instrument are Mathematics, Science, Engineering and Technology, and the 21st Century Skills. The Cronbach's alpha reliability coefficients of the Turkish version of the scale are 0.94 for STEM Attitude Scale (37 items), 0.89 for Mathematics dimension (8 items), 0.86 for Science dimension (9 items), 0.86 for Engineering and Technology dimension (9 items), and 0.89 for 21st century skills dimension (11 items). Confirmatory factor analysis fit index values ($\chi 2/df = 4.72$, RMSEA = 0.06, GFI = 0.87, AGFI = 0.85, NFI = 0.95, and CFI = 0.96) show that Turkish version of STEM Attitude Scale has a good level of fit (Yildirim and Selvi, 2015). STEM attitude scale was administered the first (pre-test) and last day (post-test) of the camp.

Camp and activity evaluation forms were designed to investigate the views of the participants on the camp and its activities. Camp evaluation form consists of three questions such as what are the aspects of the camp you like?, what are the aspects of the camp you do not like?, and what would you like to add to the camp? Activity evaluation form included three questions such as what are the aspects of the activity you like?, what are the aspects of the activity you do not like?, and what would you like to add to the activity? for each activity. These two forms were administered the last day of the camp.

Researcher observation notes were used during the implementation in order to observe directly effect of activities on participants' science and engineering practices. Two independent researchers took the notes on what the students were doing while engaged in the activities. Researcher observation notes have written under eight categories included asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information (NRC, 2011).

Artifact evaluation forms were developed by the three experts who have Ph.D. in Science, Mathematics, and Technology Education to evaluate the aspects of the artifacts. There was a unique form for each kind of artifact. These forms are based on the evaluation of common qualities as general evaluation and artifact design and functionality and evaluation of specific artifacts qualities. Common qualities included the criteria of the general evaluation such as "does the artifact involves STEM disciplines?", "related disciplines" etc. In addition, artifact design and functionality qualities included "artifact works properly?" and "artifact can be used as an independent user" etc. Artifact-specific criteria included particular artifact properties.

Data Analysis

Quantitative data obtained from STEM attitude scale were comparatively analyzed. The data checked for normal distribution with Shapiro Wilks test to decide using parametric or non-parametric statistics. According to Shapiro Wilks test results, it was found that data were not normally distributed (pre-test, $W = .66$, $p < .05$ and post-test, $W = .88$, $p < .05$). In order to compare pre-test and post-test scores of STEM attitude scale, Wilcoxon signed-ranks tests were used. The qualitative data obtained from Camp and activity evaluation forms were analyzed via inductive content analysis (Patton, 2002). Camp and activity evaluation forms were analyzed by two researchers using open coding to code participants' responses independently. The researchers discussed the emergent codes to reach a consensus for themes. After this process, themes, sub-themes, and codes were presented as a table with frequency. Researcher notes were analyzed using theory-driven content analysis (Krippendorff, 2004). The initial themes were identified under eight categories specified by NRC (2011) such as developing and using models and planning and carrying out investigations etc. Researchers' notes evaluated by two researchers based on the eight categories. Each written note categorized under a theme with a consensus of researchers. Themes and categorized observations were presented as a table. Two researchers from the project team evaluated the artifacts that the participants designed individually or as a group. Unique evaluation forms for each artifact were applied by two researchers and the consistency of the forms was calculated for their artifact to each kind of design. In this context, inter-rater reliability (IRR) of evaluation forms ranged from 92% to 100%.

Results

The Results of Attitudes towards STEM Fields and 21st-Century Skills

In order to investigate the effect of the camp on students' attitude STEM fields and 21st-Century Skills, STEM Attitude Scale pre-test and post-test scores were utilized. Wilcoxon signed-ranks tests regarding STEM Attitude Scale pre-test and post-test scores were shown in table 1. According to table 1, Wilcoxon signed-ranks tests revealed a statistically increase mathematics attitude, $z = -2.96$, $p < .05$, science attitude, $z = -3.18$, $p < .05$, and STEM attitude, $z = -3.12$, $p < .05$. The median score on the STEM attitude scale increased from before camp (mathematics $Md = 37$, science $Md = 38$, and STEM attitude $Md = 166$) to after camp (mathematics $Md = 39$, science $Md = 43$, and STEM attitude $Md = 175$). On the other hand, there were not any statistically differences between engineering and technology attitude, $z = -1.93$, $p > .05$, and 21st-century skills, $z = -1.12$, $p < .05$, pre-test and post-test attitude scores. In general, the Science and Nature camp had a positive effect on participants' STEM attitudes. The activities contributed positively to participants' attitudes towards four dimensions such as Mathematics, Science, Engineering and Technology, and 21st-Century Skills attitude. Statistically, the camp increased mathematics and science attitude of participants. It is obvious that participants were engaged in mathematics and science in formal learning environments. Therefore, they have much experience in these areas. The science and nature camp was organized to balance these four dimensions. But, only mathematics and science attitudes significantly changed because the participants' experiences and skills overlapped with new learning and concepts. It is important to create enriching learning environments with 21st-Century skills and engineering and technological skills attitudes training qualified and productive individuals in the future. However, a certain process is required for the development of these attitudes. STEM education programs need to be revised to support this process with long term interventions.

Table 1. Wilcoxon signed-ranks tests regarding STEM Attitude Scale pre-test and post-test scores

Dimensions	Pre-test-Post-test	*n*	Mean rank	Sum of ranks	*z*	*p*
Mathematics	Negative ranks	4	9.00	36.00	-2.96*	**.00**
	Positive ranks	18	12.06	217.00		
	Ties	7				
Science	Negative ranks	4	11.25	45.00	-3.18*	**.00**
	Positive ranks	21	13.33	280.00		
	Ties	4				
Engineering and Technology	Negative ranks	5	10.70	53.50	-1.93*	.06
	Positive ranks	15	10.43	156.50		
	Ties	9				
21st-Century Skills	Negative ranks	9	12.75	204.00	-1.12*	.26
	Positive ranks	16	13.44	121.00		
	Ties	4				
STEM Attitude	Negative ranks	5	13.20	66.00	-3.12*	**.00**
	Positive ranks	23	14.78	340.00		
	Ties	1				

* Based on negative ranks

The Results of Feedbacks on The Camp and The Activities

In order to investigate participants' views on the science and nature camp, evaluation forms were used. The themes obtained from the camp evaluation forms are positive aspects, negative aspects and suggestions. The themes, sub-themes, codes, and frequency values of codes regarding participants' views on science and nature camp are presented in table 2.

Table 2. Participants' views on science and nature camp

Theme	Sub-Theme	Code	*f*
Positive Aspects	Activities	Enjoyable experiment and activities	16
		The activities which foster curiosity	5
		Designs	9
		Technical trips	8
		Discovering with the activities	8
	Environment	Foods	11
		Being inside the nature	7
		New friends	9
	Project team	Kind project team	7
		Communicating with scientists	4
Negative Aspects	Activities	Number of swimming activities	3
	Other	Busy program	4
Suggestion	Activities	Hiking	3
		Breaks and sport activities	4
		More activity	3
		More archaeology	4
		More astronomy	3
	Other	Longer camp duration	4

When the table 2. is examined, it is seen that the participants' views on the STEM based Nature Science camp were gathered under the positive aspects theme, included activities, environment, and project team sub-themes, negative aspects theme, included activities and other sub-themes, and suggestions theme included activities and other sub-themes. Participants often considered activities as enjoyable (f = 16), fostering curiosity (f = 5) and supporting discovery (f = 8). It can also be seen that design-focused activities (f = 9) and technical trips (f = 8) were positively evaluated by participants. Moreover, it is understood that being inside the nature (*f* = 7), communicating with a scientist (*f* = 4), kind project team (*f* = 7), and new friendships (*f* = 9) are emphasized when the positive aspects theme of the participants are taken into account. When the negative aspects are examined, low number of swimming activities (*f* = 3) and busy program (*f* = 4) codes can be seen. According to participants' suggestions, it is seen that hiking (*f* = 3) and breaks and sports activities (*f* = 4) were demanded by participants. Furthermore, participants especially considered that more archeology (*f* = 4) and astronomy (*f* = 3) activities should be provided and camp duration (*f* = 4) should be extended.

Table 3. Participants' views on the activities

Theme	Sub-Theme	Activity	*f*
Positive Aspects	Interesting	Mathematical Designs with Origami	8
		Technical Visit II: Materials Engineering	8
		The First Step in the Engineering: A Bridge Design	7
		I meet with the Night Sky	7
	My own design	Designs in the Light of the History: From Invisible Steam to Magnetic Field	18
		The First Step in the Engineering: A Bridge Design	16
		Design a Rocket	12
		Bring Cosmos into the Classroom: 3D Hologram	11
		My Eyes are Always on Sky	10
		Makey and Coding	8
		Design a Musical Instruments from the Nature	7
	Enjoyable	The Predictions about the Next Century	9
		Bring Cosmos into the Classroom: 3D Hologram	8
		My Science Hero	6
		Mathematical Designs with Origami	5
		Design a Rocket	4
	Teamwork	Design a Rocket	6
		The First Step in the Engineering: A Bridge Design	6
		Astronomy-I-II-III	5
		The Nature of Science: Archeology	4
	Observation	Technical Visit II: Materials Engineering	14
		I meet with the Night Sky	8
		The Natural Richness of Sedir Island: Endemic Flora and Fauna	7
		Astronomy-I-II-III	6
		My Eyes are Always on Sky	6
	Experiments	Can Nanotechnology Protect Us From Rain?	13
	Using science equipment	Design a Musical Instruments from the Nature	7
		Technical Visit II: Materials Engineering	14
		Astronomy-I-II-III	16
	Feel like a scientist	Astronomy-I-II-III	14
		Technical Visit II: Materials Engineering	14
		The Nature of Science: Archeology	13
		Typical Day for a Scientist: From Mythology to Archeology	9
		The Natural Richness of Sedir Island: Endemic Flora and Fauna	7
		The Lands which the Science Births: Caria	5
		Aquatic Technical Visit III: Creatures	5
	Being in nature	The Nature of Science: Archeology	16
		The Natural Richness of Sedir Island: Endemic Flora and Fauna	11
		The Lands which the Science Births: Caria	6
Negative Aspects	Lack of time	Design a Musical Instruments from the Nature	3
		Makey and Coding	3
Suggestion	More time	Design a Musical Instruments from the Nature	4
		Makey and Coding	3
	Designing more advanced artifacts	Bring Cosmos into the Classroom: 3D Hologram	11
		Design a Rocket	9
		My Eyes are Always on Sky	6
		The First Step in the Engineering: A Bridge Design	5
		Designs in the Light of the History: From Invisible Steam to Magnetic Field	2

It should be taken into consideration that learners are "human beings" in the organization of STEM education environments. The concerns of a scientist who studies on living creatures in a laboratory or a doctor who studies with a patient do not harm to a living creature and they try to make him feel comfortable. In a similar manner, the comfort and motivation of the learners should be kept at a high level in learning environments. If you want to develop creative thinking skills, learners should be kept away from nervous environments and a cool environment should be created. Participants' views on science and nature camps are usually focused on the situation that they felt comfortable and happy such as involving enjoyable experiment and activities, making new friends, eating delicious foods, and communicating with scientists. This showed that they were happy about the science and nature camp in general terms. In addition, negative aspects and suggestion about the nature and science camp showed that they desired to create a more comfortable atmosphere for them.

The activity evaluation form used for examining participants' views on activities. The participants' responds gathered under three themes such as positive aspects, negative aspects, and suggestion. The themes, codes, and frequency values of codes regarding participants' views on activities are presented in table 3. Table 3 shows that the participants' views on the activities in the STEM-based Nature Science Camp that are collected under the theme of positive aspects, negative aspects, and suggestions. Majority of the activities considered as favorable by participants. Under the positive aspects theme, there are nine themes such as interesting, my own design, enjoyable, teamwork, observation, experiments, using science equipment, feel like a scientist and being in nature sub-themes. Particularly, design-based activities and activities supporting to work as a scientist were most favorable activities for participants. Under my own design sub-theme, Designs in the Light of the History: From Invisible Steam to Magnetic Field (f = 18) and The First Step in the Engineering: A Bridge Design activities (f = 16) have come to the forefront. For example, a participant (P5) stated "We build a paper bridge and it carried 12 kg. It was very cool." and another participant (P26) commented, "I created an electric motor and I was the fastest one." Under feel like a scientist sub-theme, Astronomy-I-II-III (f = 14), Technical Visit II: Materials Engineering (f = 14), and The Nature of Science: Archeology (f = 13), activities were very fascinating for participants. A participant (P19) remarked "I discovered a new constellation like Tycho Brahe.", another participant (P3) expressed "That day I observed atoms via electron microscopes. I talked with them (physicists) like my colleagues." one participant (P3) stated "Being an archaeologist is a job that needs to be very careful. If you miss a little part of the remains, it could be very hard to understand the whole remains." Under negative aspects theme, only one sub-theme can be seen as lack of time. According to some participants, there was not enough time to accomplish Design a Musical Instruments from the Nature (f = 3) and Makey and Coding (f = 3) activities. Finally, it can be seen that suggestion theme includes more time and designing more advanced artifacts sub-themes. Some participants recommend more time for Design a Musical Instruments from the Nature (f = 4) Makey and Coding (f = 3) activities. Especially, for Bring Cosmos into the Classroom: 3D Hologram (f = 11) and Design a Rocket (f = 9) activities, participants desired designing more advanced artifacts such as human-size hologram and a model rocket respectively. As an example, a participant (P25) stated "We could build my hologram in my body size." and another participant (P8) remarked "I could design a rocket which can reach too high if I generate enough thrust. But I need some chemicals."

When these results are evaluated in general, the participants' views on the activities depended on "how much the activity influenced their senses". This situation is similar to the participants' views on the science and nature camp. The positive aspects of the science and nature camp were overlapped with positive aspects of the activities. Features that are emphasized in positive aspects for activities were interesting, enjoyable, and feel like a scientist. Another noticeable situation about activities is that when the activity contributes to participants existing skills, participants evaluated activity as positive. For example, making their own designs and using science equipment fostered their self-confidence. The negative aspects and suggestion about activities such as lack of time and more time for some activities became prominent. As in popular culture, the individual is involved in the competitive environment by narrowing down the processes that make him happy. This means he makes concessions from he liked. Therefore, learning environments must be organized by extending over a period of time. Organizing a single theme-focused sequential activities such as robotics and artificial intelligence may deal with these participants' concerns. In addition, participants were expected to design real-like artifacts. These kinds of artifacts may contribute more meaningful learning.

The Results from Observation Notes about The Activities

In order to investigate directly effect of activities on participants' science and engineering practices during the implementations, researcher observation notes were used. Table 4 provides a synopsis of researchers notes on what students reflected during some activities.

Table 4. Example excerpts from researcher observation notes about some activities

Aspects	Observation/Evidence	Activity
Asking questions and defining problems	Why can't we see stars in the day time?	I meet with the night sky
	Which bridge design holds the most weight?	The First Step in the Engineering: A Bridge Design
Developing and using models	Determining the maximum magnification limit of the proposed telescope model.	My Eyes are Always on Sky
	Creating sky map model with data obtained from the night sky observations.	Astronomy I-II-III
Planning and carrying out investigations	Excavating and combining the remains in accordance with the scientific processes.	The Nature of Science: Archeology
	Observing the certain species.	The Natural Richness of Sedir Island: Endemic Flora and Fauna
Analyzing and interpreting data	Interpreting the data obtained from weight-bearing capacity of folded papers.	The First Step in the Engineering: A Bridge Design
	Taking into consideration to error margin when finding the focal lengths of the convex lenses.	My Eyes are Always on Sky
Using mathematics and computational thinking	Creating appropriate mathematical visuals for designing complex geometric shapes.	Mathematical Designs with Origami
	Determining the angles between rocket fins by calculations.	Design a Rocket
Constructing explanations and designing solutions	Explaining the formation of the colored shadow by propagation of light.	The Innovative Light Experiments and the Colors in Nature
	Design a car that can turn right and left.	Makey and Coding
Engaging in argument from evidence	Making interpretation about the ancient culture by observing the remains of the ancient city.	The Lands which the Science Births: Caria
	Comparison of body characteristics of freshwater and saltwater creatures.	Technical Visit III: Aquatic Creatures
Obtaining, evaluating, and communicating information	Presenting scientific predictions for the future as a poster.	The Predictions about the Next Century
	Comparing scientific predictions and data in history of science.	Designs in the Light of the History: From Invisible Steam to Magnetic Field

According to table 4 it is seen that activities included science and engineering practices such as asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. In particular, participants' science/engineering based questions (Why can't we see stars in the day time? -P13-, I meet with the night sky and which bridge design holds the most weight? -P9-, The First Step in the Engineering: A Bridge Design) were a sign of their reflection about asking questions and defining problems aspects. In Astronomy I-II-III activities, participants created a sky map model with data obtained from the night sky observations. This model was a representation tool for participants' ideas and explanations. It was an indicator that developing and using models aspect supported in that activity. Many of the activities focused on the scientific investigation such as "The Nature of Science: Archeology" activity. The participants excavated and combined remains systematically in accordance with the scientific processes. Thus, planning and carrying out investigations aspect was supported. As a result of scientific investigations in many activities, a variety of data obtained. Participants analyzed these data to reveal patterns and trends and derive meaning. For example, in "The First Step in the Engineering: A Bridge Design" activity, participants interpreted the data obtained from weight-bearing capacity of folded papers to reach the best design. These kinds of observations were the signs of that analyzing and interpreting data aspect supported via activities. Using mathematics and computational thinking aspects used in especially in design based activities such as "Mathematical Designs with Origami" and "Design a Rocket" activities. For example, participants determined the angles between rocket fins by calculations to proper flight. These kinds of observation were an indicator that constructing explanations and designing solutions supported in some activities. Also, activities fostered argumentation process. For example, in "The Lands which the Science Births: Caria" activity, the participants made an interpretation about the ancient culture by observing the remains of the ancient city using explanations and then solutions were reached. It is an indicator that engaging in argument from evidence aspect was used. The last aspect is obtaining, evaluating, and communicating information. This aspect supported by many activities such as "The Predictions about the Next Century" activity. The participants communicated about the ideas and methods when they generated particularly in group activities. For example, they presented scientific predictions for the future as a poster with their peers.

Reading a book is a skill. But reading a book regularly is a behavior. Playing the piano is a skill. When the individual plays the piano regularly to develop himself, it is a behavior. In this process, science and engineering practices serve exactly this situation. These eight seen behaviors above are the behaviors that are expected to be observed in the STEM education programs repeatedly. In this context, observing these behaviors in the science and nature camps for STEM education is vital for the development of thinking and working like scientists and/or engineers.

The Results from The Assessments of Participants' Artifacts

The artifact evaluation forms used to investigate participants' artifacts designed as individually and group. When artifact evaluation forms were examined, it is understood that the majority of the artifacts focused on STEM disciplines and the interaction of STEM disciplines. The artifacts were based on physics, astronomy, mathematics, engineering, technology, archeology, music, coding, and many other disciplines. These designs were created in different disciplines. That contributed to the participants discovering the diversity and integrity of science. Designing artifacts based on different scientific principles and concepts supported design based learning. The inclusion of different variables in the design of each artifact allowed participants to use the process of thinking with variables. In addition to that, the artifacts provided many qualities based on design and functionality criteria such as artifact, ease of use and easy storage. This is an indicator of the transformation of scientific knowledge into functional artifacts through an artifact-oriented approach based on the engineering design process.

The evaluation of the artifacts turns into an ineffective evaluation when it conducted superficially such as successful/unsuccessful or good/bad. On the contrary, dividing artifact evaluation into categories with certain features provides facilitators a scientific assessment to the effectiveness of STEM education. In addition, facilitators who already know these features can enrich the learning environments.

Discussion and Conclusion

Gifted students have great potential to deal with global economic challenges. However, there are no sufficient learning opportunities for these students for STEM education (Jolly, 2009). MUBEM & SAC: STEM Based Science and Nature Camp gave an opportunity to sixth and seventh grade gifted student by engaging STEM concepts in the informal learning environment. The science and nature camp was a unique program shaped and formed the ideas such as to foster holistic science viewpoint and scientific culture, to transfer scientific knowledge into an artifact using curiosity and scientific inquiry, to experience outdoor learning environments and scientific researches with scientists, and to support career choices of participants for STEM fields. For this purpose, it was aimed to support the intellectual development of gifted students and use the skills they possess in the short term. These learning outcomes can serve to bring society closer to scientific and artifact-oriented thinking in the long term.

According to STEM attitude scale applied as pre-test and post-test. It was seen that there was a significant difference in mathematics, science and STEM attitude in favor of post-test. This is an indication that these two dimensions and in general the attitudes of the participants towards STEM are supported in the positive direction. When research literature is examined, it is found that STEM education positively contributes to STEM attitudes of students (Ball, Huang, Cotton, and Rikard, 2017; Damar, Durmaz, and Önder, 2017; Mohr-Schroeder et al., 2014). For example, Mohr-Schroeder et al. (2014) reported that the summer science camp, which includes STEM activities, increased the STEM attitudes of middle school students. Similarly, Damar et al. (2017) concluded that robotic-related STEM activities support the STEM attitudes of middle school students. However, no significant difference was found in the dimensions of Technology and Engineering and 21st-century skills in the current study. A longer program is needed to improve attitudes in these dimensions.

The integration of STEM disciplines, social sciences and arts contributed greatly to the constitution of a holistic view of science. According to these results, the researcher observation notes and activity evaluation forms also reveals similar evidence. Because the participants experienced various disciplines, they created artifacts on the basis of scientific knowledge and process with the scientists. These artifacts created with variety of disciplines. In addition, the ability to think with variables that shape creative thinking skills constitutes the basis of design activities in particular. Taking into account the artifact evaluation forms, it can be understood that the participants designed different and creative artifacts. According to literature, it is seen that researches about the evaluation of students' artifacts are limited (Brozis and Świderski, 2018; Hathcock, Dickerson, Eckhoff, and Katsioloudis, 2015). For example, Brozis and Świderski (2018) evaluated the features of a planetarium designed by university students. The researchers stated that the artifacts were durable, functional and made with simple and inexpensive materials. Hathcock et al. (2015) examined the effects of STEM activities on the student's artifacts. The results of the research revealed that the student's artifacts were creative.

According to researcher notes, students have developed their thinking skills as a scientist/engineer. Participants gathered with experts from different disciplines during the project to get detailed information about their profession. They have experienced discussing with experts from many different disciplines such as astronomy, material engineering, and archeology. Participants found answers such questions that how does a scientist (an archaeologist, physicist, and engineer, etc.) work? and how does the scientist do research? at first hand. Meeting with the scientist allowed participants to find role models in the selection of professions. With these experts, participants had the opportunity to recognize or use the scientific devices used by scientists such as electron microscopes and telescopes. However, further investigation is needed on gifted students' long-term possible pursuit of STEM carriers.

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Students' Understanding of Calculus Based Kinematics and the Arguments They Generated for Problem Solving: The Case of Understanding Physics

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Abstract

The present study explores students' understanding of calculus-based kinematics (henceforth, CBK), in which argumentation is taken as the sequence of the modes of fostering reasoning and problem-solving. The investigation stresses the importance of arguments students bring to the learning situation of CBK and recognizes the active construction of meaning which goes on constantly as they interact with their learning environment. The study adopted mixed-methods in which one-group pre-posttest design with supplemental questionnaires and interviews were used. Data included video recordings of pre-posttests activities, as well as students' handwritten work. The pre-posttests evaluated the dependent variables (understanding CBK concepts and solving problems inspired by CBK), the treatment was argumentation. No strong causal relationship is assumed but the analyses of the results tend to show that the treatment improves slightly students' understanding of CBK concepts and their ability to identify relevant knowledge of these concepts for problem-solving. Implications of the findings for educational practice are discussed.

Introduction

Physics is about understanding; it is one of the ways we attempt to answer the perennial questions about the physical world. To understand something is to know and to find (or construct) a plausible schema, which allows one to assimilate it to what one already knows (Voss, 2006). A schema is a mental representation of a category. It is thus a concept, some information in memory that allows a person to sort various stimuli into members and non-members of that category. Research on student cognition has shown that learning is to be understood as a process in which the student actively builds-up a personal knowledge structure (Shekoyan & Etkina, 2007). This process can only be studied in relation to some particular subject-specific knowledge. Neither intelligence nor strategies will suffice for the solution of complex and interrelated problems, for example, calculus-based kinematic problems, if the domain-specific knowledge is not applied (Rhoneck, Grab, Schaitmann & Volker, 1998). This implies that physics teachers need to take into consideration the subject-specific knowledge of their students so as to provide them with the optimum condition for grasping concepts, laws and theories needed to interpret and predict natural phenomena (Iwuanyanwu, 2019b). From this perspective, situating argumentation as a central element of instruction in the design of a study aimed at investigating students' arguments and understanding of calculus-based kinematics is a critically important epistemic task and discourse process in science (Belland, Glazewski & Richardson, 2011; Jonassen, 2007; Ozdem, Cakiroglu, Ertepinar & Erduran, 2017; Walker and Sampson, 2013). A literature review of work in this area of physics has shown gaps in both the instructional approach and the combination of outcome variables that the current study is investigating (understanding CBK concepts and solving problems inspired by CBK).

The foregoing leads, for instance, to clarify the deep interplay of subject-specific knowledge necessary for students of this study to understand the fundamental concepts, laws and theories related to kinematic-calculus. At the core of such exposition is the requirement to consider the use of maths-in-physics. The effort to put the use of maths-in-physics on a rigorous footing has inspired many developments, such as the theory of partial differential equations, relativity and quantum relativistic theories, statistical mechanics (and the related areas of variation calculus, hydrodynamics, celestial mechanics, symplectic geometry, thermodynamics, electricity, aerodynamics, and so on). This has gradually supplemented by topology and the use of geometry that play an important role in string theory. In this sense, the use of maths-in-physics covers a very broad academic realm and is sometimes used to denote problem solving to describe quantitative and spatial relationships of the physical environment (Redish & Kuo, 2015). Of direct relevance of physics to the conceptualization of mathematics, physics seeks through the use of inquiry to describe and explain generalized patterns of events in the physical world (Meli, Zacharos & Koliopoulos, 2015). However, a common learning objective in both mathematics and physics is to engage students in developing and evaluating arguments (Belland et al., 2011; Redish & Kuo, 2015). In the present study students must, at the very least understand the interplay of heuristics, intuitive, and arguments suitable for the applications of calculus in kinematics problems.

Most written accounts of application of calculus in vector-kinematics make the point that students should be guided to acquire genuine explanatory knowledge through explicit teaching of argumentation (Bing & Redish, 2009). Here to explain is also to understand. For physics students to increase their understanding of application of calculus in vector-kinematics is just for them to make explanatory connections, and to see the blending of maths-in-physics connections. This is a point often missed by some science and mathematics educators. A student may know that a lot of rules hold when deriving calculus-kinematic equations using constant acceleration, but understand nothing in the sense that they make no links between the various calculus variables they know. As an example, students may know by definition that acceleration is the first derivative of velocity with respect to time $a = \frac{dv}{dt}$ and that $dv = adt$, relates to this by integration $\int_{v_0}^{v} dv = \int_0^t a\,dt$, but not see that each side of the equation is explanatorily linked to the other. As such their understanding of the interconnectedness provided by the tenets of calculus-kinematic equations is missing. Both fundamental and derived calculus-kinematic equations can potentially support and complement each other (Hashemi, Abu, Kashefi & Rahimi, 2014) and allow fuller understanding of problems inspired by mathematical physics (Bing & Redish, 2009). The level of understanding of application of calculus in vector-kinematics and the extent, to which they are applied, of course, vary according to the type of instruction given and the students' abilities to use relevant knowledge resources to construct sound arguments.

Purpose of the study

The driving aim of this study is to investigate second year physics students' understanding of calculus-based kinematics and the nature of arguments they generate while solving problems. To achieve this, the study examined two phases: a) arguing to learn i.e. treatment for understanding the concepts of calculus-based kinematics, and b) solving calculus-based kinematics problems.

Theoretical Framework

A fundamental characteristic of physics or any field of inquiry is the use of a paradigm or a library of knowledge (i.e. laws, theories, concepts, models, skills and associated processes) which serve as a framework of reference (Feynman, 1992). In light of this, the present study is situated within the argumentation framework. The evidence that exists suggests that argumentation is fostered by a context in which student-student interaction is permitted and fostered (Erduran & Jimenez-Aleixandre, 2012; Evagorou & Osborne, 2013; Ghebru & Ogunniyi, 2017). The practical point, of course, is that argumentation has three generally recognized forms: *analytical*, which is grounded in the theory of logic and proceeds inductively or deductively from a set of premises to a conclusion; *dialectical*, which occurs during discussion or debate; and *rhetorical*, which is employed to persuade an audience (Toulmin, 2003). In this study, argumentation developed by students to clearly demonstrate an understanding of calculus-based kinematics (CBK) and solve problems, which involve CBK concepts is a combination of analytical and dialectical elements. If these two forms are successful, the rhetorical form of argumentation occurs and can be documented. In most studies with this focus, the analysis of argumentation practices is based on Toulmin's (2003) Argumentation framework with the following elements: claims, data, warrants, qualifiers, and rebuttals. Claim is an assertion in need of evidential support. Data is evidence used to support a claim. Warrant or justification - connects the evidence with the claim. Backings support the validity of the warrants. Qualifier refers to conditions in which the claim is valid. Rebuttals are statements which show the claim to be invalid. From this perspective, any argument relies on an evidential base which consists of supporting data whose relationship to the claim is elaborated through the warrant, which in turn, may be dependent on a set of underlying theoretical presumptions or backings (Simon, Erduran, & Osborne, 2006).

In the literature, learning about the application of calculus-based kinematics equally requires formal modes of understanding, using precisely defined symbolic notations and explicit rules for their manipulation (Hashemi et al., 2014; Mason, Stacey, & Burton, 2010; Tall, 2012). From maths-in-physics perspective, formal modes of understanding involve exploiting mathematics and logic (or arguments) that are widely used in physics (Govender, 2007; Kiray & Kaptan, 2012; Reif, 1995). This is because mathematics is the science of valid arguments (Redish & Gupta, 2010). This implies arguments where if the assumptions are true, then the conclusion, reached by accepted rules of logic and known mathematical facts, are also true (Belland et al., 2011; Voss, 2006). Furthermore, formal modes of understanding requires the ability to assess students' reasoning at each stage in the process of developing argumentation skills and the understanding of any particular concepts, such as calculus-based kinematics as well as solving problems. However, what is currently known or believed is that the use of calculus-based kinematics problem solving to enrich students' learning and understanding of physics concepts requires teachers' awareness, understanding, and support in their teaching (Kuo, Hull, Gupta & Elby, 2013; Meli et al., 2015; Tall, 2012). An important issue flowing from this is that there are many different calculus symbolic notations to denote vector-kinematics, and students often get confused in using them in physics (Govender, 2007). Previous studies have shown that students also experience difficulties with kinematics concepts of displacement, velocity and acceleration, and in applying the concepts of calculus within problem contexts (Stacey, 2006; Tall, 2010). Although some new methods have been invented to support students' understanding of calculus, especially derivation (Ghanbari, 2012; Mason et al., 2010), but according to Hashemi et al. (2014), Roknabadi (2007), and Azarang (2012) undergraduate students have serious difficulties such as learning calculus-based courses in undergraduate level. However, science and mathematics education reformers are of the view that using argumentation as a form of discourse and explicitly teach about task structuring and modeling could provide a useful anchor for new learning (Bing & Redish, 2009; Erduran et al., 2004; Evagorou & Osborne, 2013; Kuo et al., 2013).

Bind and Redish's (2009) study similar to the present study have analyzed students problem solving using math in physics. From videotaped observations of intermediate level students solving problems in groups, they note that students often get stuck using a limited group of skills or reasoning and fail to notice that a different set of tools (which they possess and know how to use effectively) could quickly and easily solve their problem. For the context of mathematics use in physics problem solving, they presented four dimensions (calculation, physical mapping, invoking authority, and math consistency) for classifying physics students' epistemological framing via warrants. Regarding the four dimensions, there is a more general point about distinguishing a calculation framing from physical mapping framing. The distinction between them concerns a student's in-the-moment awareness of the physical referents of his/her math-in-physics. The idea of invoking authority is another aspect which illustrates how a student can forage his/her knowledge resources during physical referents. An invoking authority stems from framing ideas, laws and theories which are closely tied to finding the right level of detail to go into during a problem solving. The fulfillment or the attainment of the latter is referred to as math consistency by Bing and Redish (2009). A lesson learned from their study is that using the four dimensions they identified to classify warrants could provide a useful lens on the development of students' problem solving skills. This is worthy of consideration in the present study. Thus, two issues are relevant here. The first issue is the nature of arguments students generate to develop criteria for establishing a reasonable solution pathway. Here their thinking is dynamic. They need to identify or recognize instances of valid and invalid arguments pertaining to CBK, for example, the class of warrants such as computational steps of algorithm relevant to set of relations and inferences. The second issue concerns the identification of specific warrants used, like all the other warrants, especially those that are shared because both educator and student frame the discussion as calculation. Again, it is through identifying these (relatively explicit) warrants that the researcher can get information about relatively implicit "epistemological framing" process in the student's mind (Bing & Redish, 2009, p. 9).

Method

This study followed a mixed-methods approach in which one-group pre-posttest design was supplemented with interviews and questionnaires. The pretest evaluated the previously mentioned dependent variables. The treatment was argumentation (i.e. arguing to learn). The posttest evaluated the dependent variables and interviews.

Participants

An intact second year undergraduate physics class of 86 students (49 males, 37 females) served as the research participants. Students ranged between 19 and 23 years old. Most of these students were from middle-class families. The students learning majors are physics, chemistry and biology. During the first year of their study they are required to do calculus-based modules for use in the previously mentioned majors. Less expected of the students in their second year is to demonstrate poor understanding of calculus-based kinematics.

Procedure

This 13week (two class periods of 180 min per week: a double class period of 120 min on Monday and a single class period of 60 min on Wednesday) study included two phases: arguing to learn (treatment for understanding the concepts of calculus-based kinematics, and solving calculus-based kinematics problems. A week before treatment commenced, a handout was provided to the students including information about different phases of the study, differences between the procedures, the role of the educator and expectations from students, purpose of the study, and instruments and instructional materials to be used during treatment. Normatively, students receive instruction through conventional method of teaching. As such, they have not been exposed to argumentation instruction before this study. The intention of selecting *arguing to learn* (treatment) was to offer students new learning opportunity to nurture their understanding of calculus-based kinematics, and (if successful), then it will lead to transforming the physics teaching practices in the context of calculus-based kinematics. The experienced educator had 12 years of physics teaching and practical experiences in argumentation teaching. The instructional context followed students' lecture timetable for physics. As such, no instructional time was wasted. The physics educator taught the calculus-based kinematics, a unit section of the physics course that most students find difficult to understand. The pretest and posttest took two class periods each (120 min in weeks 1 and 12). The interviews took one class period (60 min in week 13). Week 2 and the remaining class time in weeks 3 – 11were focused on the treatment.

Learning Material: Calculus-based kinematics (CBK)

In designing the learning material used in this study several issues were considered. For example, most calculus students tend to use analytical strategies to compute derivatives and integrals (Eisenberg & Dreyfus, 1991), and this tendency makes it more difficult to infer students' strategies when they are solving procedural tasks (Haciomeroglu, Aspinwall & Presmeg, 2010). Thus, the learning material CBK was designed to develop information-rich cases of students' arguments and understanding of calculus-based kinematics. The CBK was enriched with activities related to kinematics concepts of displacement, velocity, time and acceleration, and integrated the practices of arguing to learn (Walker & Sampson, 2013). The content of the CBK activity was obtained from three physics textbooks that students were using at the time of the study (e.g. Introduction to physics by Cutnell & Johnson, 2013, Fundamentals of physics by Walker, 2008, and Physics principles with application by Giancoli, 2005). CBK expects students to focus on important parts of nurturing their understanding of symbolic notations and reflecting on various aspects of sentential calculus. It makes deriving equations of motions much simpler for the students in the study. For instance, in deriving the second equation of motion, by definition, velocity is the first derivative of position with respect to time. Instead of differentiating position to find velocity, the operation in the definition was reversed such that the integration of velocity was used to find position. Doing so offers the students in the study to grasp the kinematic-calculus concepts easily than was previously the case. The following step-by-step description of kinematic-calculus derivation is an example of how the learning material portrays teaching for understanding to the students. In deriving the second equation of motion inspired by calculus, it started with $v = \frac{ds}{dt}$, followed by $ds = v\,dt$, which can be expressed as $ds = (v_0 + at)dt$. The latter follows the integration of velocity to find position $\int_{s_0}^{s} ds = \int_0^t (v_0 + at)dt$. From this we get ($s - s_0 = v_0 t + \frac{1}{2}at^2$), which gives us the position-time equation for constant acceleration ($s = s_0 + v_0 t + \frac{1}{2}at^2$), known as the second equation of motion.

Furthermore, the CBK activity, which took about 180 min per week during the previously mentioned class periods, taught the students to actively engage in arguing to learn. It was hoped that the CBK learning material would help students nurture their arguments pertaining to understanding of kinematic-calculus concepts, as well as solving problems involving the concepts. For the pretest and posttest items pertaining to quantitative data, there were ten questions testing for students' understanding of kinematic-calculus concepts. The ten questions placed heavy emphasis on both dialectic and analytic forms of learning. Another four questions of the same concepts tested students' problem solving skills within the context of arguing to learn. The four items placed emphasis on elements of analytic solution, whereby a student would critique or examine an equation-based problem to help him/her develop criteria for establishing a reasonable solution pathway. An example of these questions (see Q3, p.7) and how it composes dialectic and analytic utility of learning as well as how students blended auxiliary information for problem-solving organization and solution is presented in the findings and discussion section. Thus, analytic solution to a calculus-based kinematic task may involve translation of sentential calculus to an equation (or symbolic representation), computing the integral part of the equation, and then using this new equation to solve follow-up problems (Haciometroglu et al., 2014; Tall, 2012). Analytic solution also includes numeric strategies in which the students substituted values for x to find y or any other variable. In fact, analytic solution resonates well with students' analytical understanding. This is to say, however, that analytical understanding denotes mental process employed by individuals using their previous experience and mental abilities to argue, infer and understand problems and difficulties encountered in order to reach conclusions and make decisions (Zimmerman, 2007).

Moreover, data quality considerations involving the content validity of the CBK worksheet were reviewed by two physics educators who read, discussed, and reversed the worksheet to reach consensus. After attending to the revisions recommended by the previously mentioned reviewers, the CBK worksheet was resubmitted to them for final checkup. To establish the degree to which the two sections of the CBK worksheet measures: 1) students' understanding of calculus-based kinematics concepts, and 2) solving CBK problems through arguing to learn, the reliability of the CBK items was explored using internal consistency. Cronbach's alphas were computed for each section of the CBK, 1 and 2. Cronbach's α was found to be $.77$ for section 1, and $.74$ for CBK section 2. Study of Bing and Redish (2009) was taken as reference for scoring students' framing of arguments while completing the CBK worksheet.

Phase 1: Arguing to learn: Treatment for understanding the concepts of calculus-based kinematics

Phase 1 focused on two conditions related to when a student has fully understood a given kinematic-calculus concept, s/he is reasonably expected to: a) define the concept in symbolic notation, and b) recognize instances and non-instances of valid of kinematic-calculus arguments. A warm-up practice of setting out an argument was used as an introductory CBK activity that would familiarize the students with argumentation as a form of discourse and explicitly teach about task structuring and modeling (Erduran et al., 2004; Evagorou & Osborne, 2013; Ghebru & Ogunniyi, 2017; Walker and Sampson, 2013). Thus, the educator guided the students to learn and practice setting out an argument related to CBK concepts. In order to make argumentation instruction as explicit as possible, argumentative elements (e.g., claim, evidence, reasoning, counterclaim, and rebuttal) and their application within the scope of the study were explained to students. Important terms were clarified; especially those elements with overlapping meaning, for example, claim and warrant. In this regard, the overlapping elements were discriminated using words such as "because", "so" or "since" as cues to indicate data/evidence, claim and warrant, respectively (Erduran, Simon, & Osborne, 2004). That way, instances of ambiguities were relatively resolved, hence the use of the operative word "so" which itself is implied in Toulmin's definition for reaching conclusions.

Other important conditions were also explained. A reason was termed as a set of claims grouped together with cue such as "because". For example, since students were expected to provide claims for solution of the CBK problems and support their claims with evidences, a reason in this case, aims to raise a student's confidence in a conclusion. The claims comprising each reason are unified when it is plausible to support the conclusion. Further to this, to facilitate students' understanding and use of those strategies in their learning, conditions of what counts as a good argument were explained to them. The arguing to learn practice was implemented as follow: 1) Intra-argumentation i.e. the brain-storming or self-conversation stage. At this first stage, students performed individual tasks depicted in the CBK learning material which required them to define and construct valid kinematic-calculus expressions, 2). Inter-argumentation or small group discussion stage, at this point each small group of 4-6 students received tasks that required the transfer of knowledge resources of kinematic-calculus to different contexts which required different levels or types of arguments, and 3) trans-argumentation or whole-group discussion and reflection. This is the stage where collaborative consensus is reached (Ogunniyi, 2009). Students were encouraged to discuss with each other, share co-constructed knowledge and tacit understanding emanating from their learning. Thus, students reflect on and learn from what they are doing. To ascertain how well the treatment condition was implemented as planned, the average and binary complier fidelity indexes were considered to ensure a measure of the reliability of the administration of the intervention. The average fidelity index was considered by using mean scores of students' response to CBK in each test conditions (pre-test in week 1 and posttest in week 12). On the other hand, the binary complier index involved examining the distribution of students' responses in relation to achieving the minimum conditions set for learning CBK through arguing to learn. Regarding this, the baseline data were considered as a cut-point against which the following conditions were observed between weeks 2 - 11. The conditions include what Ogunniyi (2007a) described as: the ability to follow an argument (clearly a good grasp of the language used and mental alertness are critical for this to happen); a willingness to submit to the force of a better argument; the aptitude to treat each other as equal and reasonable arguers; and a willingness to learn something new. In doing so, students learn from each and had the opportunity to interrogate sentential symbolic notations of kinematic-calculus.

Phase 2: Solving calculus-based kinematics problems

After phase 1, the students were assigned problem sections of the calculus-based kinematics (CBK) learning material. They were arranged to use their learned knowledge and skills in phase 1 to complete assigned tasks. The process focused on students using the substances of arguments they had learned to solve CBK problems. The completion of the problem solving tasks took about 60 min of the single class period. Some sections of the tasks were done collaboratively as share activity in groups of 4-6 students. The educator encouraged students to discuss the instances of valid and invalid arguments of applications of kinematic-calculus concepts. He encouraged students to actively use the learned skills, but did not provide any answers (solutions) to tasks meant for use in the result section of the study.

The posttest (120 min distributed in two class periods in week 12) was administered using the same CBK learning material. For the qualitative data, the interview item was constructed to collect all students' viewpoints and learning experiences on argumentation as an instructional practice in the context of calculus-based kinematics. Since students were arranged in groups, a student was taken from each group of fourteen groups and was interviewed by the researcher. The data gathering took 60 min (in week 13), the last week of the study. The interview protocol included an introduction, rapport-building, free narrative, and closing. Students were encouraged to share their opinions about the combination of arguing to learn i.e. treatment for understanding the concepts of calculus-based kinematics, and solving calculus-based kinematics problems. The interviews were audio recorded and transcribed and transcripts were sent back to the interviewees to check their responses and the tentative qualitative outcome. In addition to this, the interview transcripts were again reviewed by the previously mentioned reviewers of the CBK worksheet. They made judgments about coding, following which they met to reach consensus regarding the codes and emergent trends.

Data analysis

Overall data treatments involved established scoring and coding techniques. The ten questions in the pre-posttests related to understanding calculus-based kinematics concepts were scored 2 points for right and 0 for wrong answers for a total possible score of twenty. The CBK scoring adopted well-developed common framings and their primary (i.e. warrants) and secondary indicators (Bing & Redish, 2009) that included four dimensions (calculation, physical mapping, invoking authority and math consistency). Each dimension was scored based on a class of warrant used and other common indicators. Scoring of the argument also depended on whether a student's response fitted Toulmin's Argumentation Pattern definition of warrant; for example, if a warrant response was a description of reasoning and relation between data and claim pertain to CBK, then the student would be scored 2 points, if not, 0 point. If a student gives a backing response, it has to strengthen the warrant by stating the causality or connection of Kinematic-calculus, and if s/he gives a rebuttal response it has to point to the condition under which the claim to knowledge would not hold true in order to receive 2 points. Since there are six elements of arguments, the total possible score for assessing students' arguments was 12. Test-retest reliability coefficient (i.e. the correlation between scores at pretest and posttest) was .76 . To this end, quantitative data included scores from the fourteen items of the CBK (pretest and posttest), whereas qualitative data were gathered from interviews, which were students' responses about their learning of CBK. Analysis of quantitative data involved calculating both descriptive and inferential statistics, testing scores of the outcome variables. Paired-sample t-tests were used to analyse pre-posttests changes in the students' arguments and understanding of CBK. The significant level was set as $p<.05$ during the analyses using the SPSS (version 25). Finally, qualitative data from interviews were analyzed using open coding (Strauss & Corbing, 1998). The researcher was responsible in analyzing the interview responses. The researcher and one of the previously mentioned reviewers of the CBK worksheet read each student's response, code them, and then grouped emerging themes to show the extent to which the students responded to the treatment (arguing to learn). Inter-rater reliability coefficient was .79 showing the comparability between coders (Miles & Huberman, 1994).

Findings and Discussion

The descriptive interpretation of the CBK performances (n = 86) revealed that the frequency and percentage of each score were: 12 points n = 15 (17%), 11 points n = 9 (10%), 10 points n = 6 (10%), 9 points n = 7 (8%), 8 points n = 5 (6%), and so on (see Table 1), and none with zero point. Sixty-nine percent of the students scored 6 or more points on the TAP component in terms of analytic and dialectic arguments, which meant that most students answered most of CBK items correctly.

Table 1 Frequency and percentage scores of students' arguments

	Frequency by (%)											
Score	12	11	10	9	8	7	6	5	4	3	2	1
Students(N = 86)	15 (17%)	9 (10%)	6 (7%)	7 (8%)	5 (6%)	10 (12%)	8 (9%)	9 (10%)	2 (2%)	7 (8%)	4 (5%)	3 (3%)

The analysis of pre-posttests scores related to students' arguments in terms of analytic and dialectic forms of learning calculus-based kinematics (Table 2) revealed significant gain, $t = -.136, p = .001$. This meant that most students demonstrated improved understanding of the content of CBK concepts over the duration of the study. Another point to consider is that there was no prediction that the effect of arguing to learn would lead to high levels of students' understanding of CBK concepts on the pretest and posttest mean scores (12.65, 12.68 respectively, out of twenty possible points). Despite this, the results arising from the data tend to show that the treatment improves slightly students' understanding of CBK concepts and their ability to identify relevant knowledge of these concepts for problem-solving.

Table 2 Pre-posttests scores in students' arguments, understanding and solving of CBK problems

	Arguments: analytic & dialectic		*Understanding content*		*Solving problems inspired by CBK*		*Total Score*	
CBK Test	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean (M)	6.57	6.92	12.65	12.68	9.66	10.48	11.67	16.88
Standard Deviation (SD)	1.64	1.56	2.57	2.89	1.83	1.36	2.72	3.74
t	–.136*		–6.71*		–7.38*		–9.89*	
p	<.001		<.001		<.001		<.001	
Cohen's d	.22		.18		.44		1.39	

*(*p<.05)*

The results (Table 2) showed significant gain between pretest and posttest scores related to understanding content of CBK. The paired-sample t-test of the students' performance on all of the posttest scoring items demonstrated significant ($p<.05$) progress over the pretest performance. The effect sizes (Cohen's d), for students' understanding of CBK were between .18 and 1.39. The improvement on the total score was a larger effect size, $d = 1.39$ and the improvements on solving problems inspired by CBK was also large effect size, $d = .44$. Given these results, it can be assumed that the arguing to learn (treatment) may have contributed to the students' performances on understanding and solving problems inspired by CBK concepts. These findings add to evidence to support the suggestions of Belland et al. (2011), Ozdem et al. (2017) and Walker and Sampson (2013) that arguing to learn could help promote students' understanding of science concepts.

How students demonstrated arguing to learn to support their understanding of CBK problem-solving

The first result from students arguing to learn that seemed to have supported their understanding of CBK problem solving comes from a group of five students responding to the following question designated as (Q3). The problem statement reads:

> An eagle flies in the xy-plane with a velocity vector given by $\vec{V}(t) = (\alpha - \beta t^2)\hat{i} + \gamma t\vec{j}$ with $\alpha = 2.4m - sec^{-1}$, $\beta = 1.6m - sec^{-3}$ and $\gamma = 4.0m - sec^{-2}$. At $t = 0$, the eagle is at the origin. (a) Calculate the position and acceleration of the eagle as functions of time. (b) What is the eagle's altitude ($y-$coordinate) as it flies over the origin ($x = 0$) for the first time after ($t = 0$).

The principal dynamic cognitive process in each of the following students' arguments concerns how they interpreted the math deeply rooted in the structure of CBK activity. Different bits of their mathematical knowledge are activated and deactivated as they frame and reframe their activity (Bing & Redish, 2009). Below are some extracts from the students' arguments that help to make the point. Two out of five students in the group did not recognize the point of the problem from the beginning. For ease of reference, students are designated as Student 1, Student 2, and so on beside their responses to help the reader follow the sequence of arguments, results and discussion. Here are some of the excerpts from the students' conversations:

Student 6: I feel that there is no obvious way to derive the equation for $\vec{a}$ without deriving $\vec{r}(t)$
Student 17: It doesn't say that in the question, does it?
Student 6: Come on you can read that, it does…
Student 17: You can read it to us for a start…
Student 17: Oh, okay…so we need to play a rather sophisticated trick…
Student 29: …say position is given by $\vec{r}(t) = \int \vec{V}(t)dt = \int(\alpha - (\alpha - \beta t^2)dt\hat{i} + \gamma t\vec{j}...$
Student 6: Angelo (pseudonym), I don't follow...the last part of the equation, check it…
Student 17: I'm not following…I understand that $\vec{r}(t) = \int \vec{V}(t)dt = \int(\alpha - ....$, but this $(\alpha - \beta t^2)dt\hat{i} + \gamma t\vec{j}...$ how come?
Student 29: It is part of the problem statement…let's go back to the question….
Student 17: Oh, there I see…
Student 6: But…Angelo, I think the integral part of the equation is this….
$\vec{r}(t) = \int \vec{V}(t)dt = \int(\alpha - (\alpha - \beta t^2)dt\hat{i} + \int \gamma t\, dt\vec{j}...$, yes this part $\int \gamma t\, dt\vec{j}$ was incomplete…

If students perceive their learning as making sense, or establishing meaning, or gaining understanding then one might reasonably expect when this happens it is something for the students to mark. Notice on one occasion when student 17 asked her peers for clarity "I'm not following…I understand that $\vec{r}(t) = \int \vec{V}(t)dt = \int(\alpha - ....$, but this $(\alpha - \beta t^2)dt\hat{i} + \gamma t\vec{j}...$ how come?" it led her to gain some insight "Oh, there I see." Student 6 must have seen the future use of this piece of mathematical equation ($\int \gamma t\, dt\vec{j}$) that student 29 may have overlooked and makes the assumption that he will have the opportunity to use it when required in problem solving. The arguing to learn continues.

Student 29: Aha okay…now, $\vec{r}(t) = \int \vec{V}(t)dt = \int(\alpha - (\alpha - \beta t^2)dt\hat{i} + \int \gamma t\, dt\vec{j}...$
Student 33: The final equation will come to this $\vec{r}(t) = \left(\alpha t - \frac{\beta t^2}{3}\right)\hat{i} + \gamma \frac{t^2}{2}\hat{j}$.
Student 52: It's now obvious we can use this equation to find position…
$\vec{r}(t) = \left[\left(\alpha t - \frac{\beta t^2}{3}\right)\hat{i} + \gamma \frac{t^2}{2}\hat{j}\right]$, right?
Student 6, 29 and 33: Yeah…
Student 17: Can we not ask sir if it is the correct equation for calculating the position?
Student 29: That won't be necessary, don't bother him…
Student 6: Clara, continue with the write-up…
Student 17: So, $\vec{r}(t) = \left[\left((2.4m - \sec^{-1})t - \frac{1.6 - \sec^{-3} t^3}{3}\right)\hat{i} + (2.0m - \sec^{-2})t^2\hat{j}\right]$
Student 17: Is that all about the substitution, anything else?
Student 29, 6 and 52: Yeah, that's the first part of the solution for position we were asked to find.
Student 33: Next, we must find the acceleration…I think it's just the easiest part of the problem…I can do that…
Student 17: I see…different from other activities we have completed earlier…like the vector function and things like that.

Despite the fact her group has just had the experience of understanding how to derive, interpret and compute the CBK problem; Clara (student17) does not identify this as part of the purpose of understanding the CBK concepts. To her, it is rather about practising routine skills.

Student 33: We can say the acceleration is given by $\vec{a} = \frac{d}{dt}\left((\alpha - \beta t^2)\hat{i} + \gamma t\, j\right)$, is this correct guys?
Student 29: …wait a minute, look what happens when we do this…we get a derivative equal to

acceleration… $-2\beta t\hat{i}+\gamma\hat{j}$
Student 6: There was nothing wrong with that.
Student 52, 6, and 17: Yeah, Brian was going to come to that…it wasn't all that more difficult than the first two derivations.

In what followed, another group of six students was invited to respond to question (b) of CBK (Q3). These extracts of students' conversations are interesting because they reveal students' separation of maths-in-physics classroom practice from their understanding of CBK problems.

Student 4: What is the eagle's altitude at the origin?
Student 19: Isn't it what we need to find?
Student 4:…I mean in real life…what's the eagle's altitude at the origin?
Student 32: Most probably the reference point before the eagle gears up into the air.
Student 85: We can only find it by solving for the time at $r_x(t)=0$.
Student 47: Do you think $r_x(t)=0$ is going to be of any use to us?...i don't understand…
Student 85: What don't you understand there?
Student 32: But the eagle's altitude is given as $(y-\text{coordinate})$ …
Student 4: I got what Solomon is saying, yes…even though it was given as $(y-\text{coordinate})$, the problem says 'as it flies over the origin ($x=0$) for the first time after $t=0$.
Student 85: That's what you would expect him to understand, except that he assumes I have no purpose of stating that $r_x(t)=0$.

The experiences of arguing to learn seem to have been guiding the students to do structured thinking by detecting that certain claims made to knowledge by their peers need to be backed up. It is useful for students to collect a variety of evidence-based claims and personal opinions from which to decide what to believe or do (Walker & Sampson, 2013). The arguing to learn continues.

Student 4: Can I solve it?
Students 85, 19 and 30: Go ahead.
Student 4: Alright, $\alpha t=-\frac{\beta t^3}{3}=0,\ \alpha t=\frac{\beta t^3}{3}$...
Student 19: And that will lead to $\alpha t=\frac{\beta t^3}{3}$, which gives us $t=\sqrt{\frac{3\alpha}{\beta}}=2.12s$, right?
Student 85, 30 and 4: Yeah, all in order.
Student 32: …then we can say with confidence that the eagle is at $x=0$ (the origin), 2.12 seconds, right?
Student 4: Yes…after $t=0$.
Student 47: But what does $r_y(t)$ equal to?
Student 30: That should be $r_x(t)=2.0m-sec^{-2}(t)$, not so?
Student 32: No, Amanda is right, we should be dealing with $r_y(t)$ and not $r_x(t)$ …we dealt with it already.
Student 47 and 4 : Guys let's move ahead, we have little time left… we know that $r_y(t)=\gamma\frac{t^2}{2}$.
Student 85: Yeah…since we now know the time is 2.12s, the eagle's altitude $r_y(t)$ at that time is, $r_y(2.12)=\gamma\frac{t^2}{2}=2.0m-sec^{-2}(2.12)^2=...$
Student 19: And that gives 9m.
Student 4: It turns out that the eagle's altitude is 9m.
Student 47: Yeah, as it flies over the origin $x=0$ for the first time after $t=0$.

Students' arguments thus suggest they were framing their activity as math consistency. For example, when student 17 asked student 29 to clarify certain part of the equation he was busy deriving, he gestures to the different paths as he points out to Student17 that what she is asking is given in the problem statement. He was more willing to negotiate meaning with her when he says "let's go back to the problem". Perhaps his intention was to use available data traceable in the problem statement to convince his peer. His data is a familiar mantra (though he omits mentioning how the equation he was deriving $\vec{r}(t) = \int \vec{V}(t)dt = \int(\alpha - (\alpha - \beta t^2)dt\hat{i} + \int \gamma t\, dt\,\vec{j}...$ is only valid for the context they were considering). Even so his warrant suggests he was framing his use of maths-in-physics in a different way. His oversight (or mistake) in dealing carefully with the last section of the equation was only realised when his peer (student 6) alerted him. Moreover, he responds to reframing request made by student 6 and repeats his equation as he remains in invoking authority. At any rate, his response shows he may have overlooked the missing part of the equation. While student 47 thinks there should be different amounts of information they need to address their own problem (Q3b), his peer (student 4) provided him a justification for the assumption, student 85 had made. As the arguing to learn progresses there were several instances in which students were able to identify both valid arguments and invalid arguments of their peers. It appeared that students were very accomplished in the practice of arguing to learn, they knew how to behave and thrive in this area. They were aware of the goals of the practice, and shared expectations which enabled them to work towards the goals.

Benefits of using argumentation instruction

The interview responses were explored to determine the benefits (if any) of using argumentation instruction on students learning of CBK concepts. The driving question is expressed in italics, students are designated using the foregoing pattern beside their responses, and the author's elaborations are in normal font.

> Interviewer: How have your experiences in the arguing-to-learn-based lectures improved your understanding of CBK concepts and problem-solving skills?
>
> Student 11: It was helpful in doing some activities, but not all. In some activities, I feel you need to concentrate and not let people distract your thinking process, especially with calculus…
>
> Student 38: Me…I feel that it was useful and practical for me. There are little difficulties of following the procedures…like in some activities we completed you find that other students' voices were minimal, some students tend to dominant the flow.
>
> Student 19: When engaging in this CBK activity, arguing to learn for me was fruitful. It helps us to provide reasons, even when we don't agree with other people's opinions…we must provide justifications to convince them about our own views on any side of issue…that for me is good.
>
> Student 52: I enjoyed it. We students could apply these concepts of warrant, backing and rebuttal into our learning of other subjects…like chemistry, biology and maths. In terms of solving problems, I must say…it leads me to make good decisions.
>
> Student 6: Before, I do not like solving problems involving calculus, now…that is changing. In our group, Angelo was very helpful. He was good in keeping ideas flowing. Some of the activities we completed together…I only understood them because of the way we were learning them.
>
> Student 85: It was helpful…the practices were sort of mental activity that helped to sharpen our skills…what else can I say, oh yes…one more thing interesting was engaging my fellow students, I learned a lot doing so.

Responses such as these led the author to believe that for the students in this study calculus-based kinematics (CBK) lessons belonged to a practice which was quite different from their own ways of learning. Student 38 shared a concern about the domineering attitudes of some of her peers during arguing to learn. She describes this as procedural difficulties. In response to this finding, this is due, to some extent, to the limited time frame involved in completing some of the CBK activities, with most activities lasting a few minutes to complete. While this poses particular pedagogical challenges insofar as facilitating arguing to learn is concerned, other researchers, who have examined the ways students participate in argumentation, have suggested that argumentation practice (or protocol – terms and conditions) must be thoroughly explained to students before exposing them to its practice (Erduran et al., 2004; Walker & Sampson, 2013). Nonetheless, data from this study also indicate that success in CBK has as much to do with learning with special discourse rules and interpreting symbolic notations in a clever way. And because of the fragmented nature of some students experience about the instructional approach they did not seek any coherence within the use of maths-in-physics and thus when it is clearly lacking it fails to interrupt their flow of activity and so there was no reason to reflect.

> Student 20: Unfortunately, I noticed no difference in my understanding of CBK concepts. I do not like to involve myself in debate activities, whenever I hear the word argument; I have a feeling of dislike.
>
> Student 45: I compete with other students for completion of most of the activities. In some cases I lost concentration, or made mistakes that I could have avoided if I were to solve the problems on my own.
>
> Student 19: Yes, yes…it has improved my understanding…I cannot speak for everyone. But from what I have noticed in my group, we were all excited whenever we set to solve problems involving calculus. One of the tricks that I think other students are failing to realize is the rules to apply.
>
> Student 34: Right from my high school days, calculus has always being inspiring aspect of mathematics that I enjoy. It is vast, complex and interesting. My father was a mathematics teacher, so in that belief I started early liking maths and sciences. So the instruction has brought more insight to my learning.
>
> Student 4: Like detectives hunting for clues and building ideas from them…that is how I will describe my experience of arguing to learn CBK. So I find it helpful.
>
> Student 1: Yes, it has offered me the opportunity to my learning of CBK and my understanding of all the physics activities we did have changed. Before arguing to learn was introduced, I was attending calculus tutorial sessions, and now I have realized what have been missing in my failed attempts to understand calculus.
>
> Student 66: To some extent, it was helpful. One thing I dislike about it is time consuming. It takes time for most of us to agree on a particular idea, even when the evidence is overwhelming. They still want to argue more and more, that to me is time wasting.
>
> Student 86: I used to be afraid whenever I am called upon to answer questions during calculus problem solving; I just think my fear has reduced. I can say it is beneficial to me and to my group because we all learn from one another…and help each other to identify mistakes.

Although calculus can be sophisticated, once its constructs are understood, students can go beyond the techniques and the symbolic manipulations to see the subject matter for what it is. Integrating argumentation experience with CBK was to encourage better and thorough understanding. Hence, through the activity of arguing to learn, the students supported their understanding of CBK problem-solving, which had significant teaching-learning benefits.

Conclusion and suggestions

This study empirically has explored students' arguments and understanding of calculus-based kinematics. In the study, argumentation in the form of arguing to learn has shown how students exert various pushes and pulls on each other as they try to negotiate a common understanding. The analysis of how students demonstrated arguing to learn to support their understanding of CBK problem-solving is necessary to discriminate how they frame their maths-in-physics activity. The evidence presented has shown that each student frames his/her CBK activity differently and hence tries to apply a different type of warrant to judge the validity of their claims. This has important implications for teachers as well as researchers in the area of this study. For example, in a conventional lecture, information on presenting CBK tends to only flow from the lecturer (educator) to the students. But engaging students in arguing to learn could be helpful to improve students' understanding of CBK concepts. And referring back to the theoretical framework which based on Toulmin's (2003) Argumentation Framework, arguing to learn is the practice which is goal directed rather than the person who enters the practice, the person is subjectified by the practice and is motivated or led by his expectations regarding needs to be fulfilled. Excerpts from the interview showed that students felt that the modalities associated with arguing to learn lead to waste of time. This point to treatment fidelity and begs for the question, was the treatment effective in promoting the desired outcomes for all the students who received it? In a way, the analysis of students' interactions with the treatment shows that it made a relative difference in supporting their understanding of CBK. There are other argumentation patterns that can be applied for classroom-based research (Erduran &

Jimenez-Aleixandre, 2012; Evagorou & Osborne, 2013; Ghebru & Ogunniyi, 2017; Iwuanyanwu, 2019a). Future studies can further investigate this dimension.

Limitations

Ideally, it would have been more fruitful to conduct this study among all the undergraduate physics students to better their understanding of CBK, but due to institutional constraints, access to students in other undergraduate physics levels was not feasible at the time of this study. The second year group included in the study was more readily accessible, hence the use of a convenience sampling. And, whilst a probability sampling technique would have been preferred, the convenience sample was the only sampling technique that allowed the researcher to gather useful data and information that would not have been possible using other sampling techniques, which require formal access to other undergraduate students. In addition, the question of whether treatment (arguing to learn) was effective in helping students to better understand CBK is treated with caution given the design of the study. On this point, since the study adopted one-group pre-posttest design which has no control or comparison group to address other external influences, thus, the study cannot speak to how much of the improvement in students' understanding of CBK are solely due to the treatment (arguing to learn). Besides, it neither generalise its findings beyond the sampling frame nor the design. However, the basic point to consider here is that knowledge gained across time (pre-test and posttest) is representative of the population from which the sample was drawn. In conclusion, the limitations pointed out should be considered in the design of future studies.

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