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Investigation of the Contribution of Differentiated Instruction into Science Literacy

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Date of publication: June 28th, 2018
Edition period: June 2018 – October 2018

To cite this article: Şentürk, C., & Sari, H. (2018). Investigation of the contribution of differentiated instruction into science literacy. *Qualitative Research in Education, 7*(2), 197-237. doi:10.17583/qre.2018.3383

To link this article: http://dx.doi.org/10.17583/qre.2018.3383

Qualitative Research in Education Vol.7 No.2 June 2018 pp. 197-237

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(Received: 23 March 2018; Accepted: 25 June 2018; Published: 28 June 2018)

Abstract

The aim of this study is to reveal contributions of the differentiated instruction implemented in the primary school 4th grade science course into science literacy levels of the students. The case study method among qualitative research methods were used in the study. The research was carried out in the second term of 2015-2016 academic year. The study group consisted of the 4th grade students (n=23, 9-10 aged) studying in the Kozabirlik Primary State School in Bilecik city center in Turkey. Interviews (teachers and students), observations and student diary forms were administrated as data collection tools in the study. The content analysis method was implemented in the analysis of the obtained data. It was concluded from the findings that the differentiated instruction improved involvements of the students with the science-technology-society and the environment and developed their scientific process skills and thus contributed to the science literacy levels of the students.

Keywords: differentiated instruction, curriculum differentiation, science literacy, qualitative research method

ISSN: 2014-6418
DOI: 10.17583/qre.2018.3383

Qualitative Research in Education Vol.7 No.2 June 2018 pp. 197-237

Investigación de la Contribución de la Instrucción Diferenciada en la Alfabetización de la Ciencia

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(Recibido: 23 de marzo de 2018; Aceptado: 25 de junio de 2018; Publicado: 28 de junio de 2018)

Resumen

El objetivo de este estudio es dar a conocer las contribuciones de la instrucción diferenciada implementado en la escuela primaria 4º curso de grado de la ciencia en la ciencia en los niveles de alfabetización de los estudiantes. El método de estudio de caso, entre los métodos de investigación cualitativa se utilizaron en el estudio. La investigación se llevó a cabo en el segundo término del año académico 2015-2016. El grupo de estudio consistió de los estudiantes de 4º grado (n=23, 9-10 años) que estudia en la Kozabirlik Estatales de Primaria de la Escuela en Bilecik centro de la ciudad en Turquía. Entrevistas (maestros y estudiantes), observaciones y estudiante de diario de formas fueron administrados como herramientas de recolección de datos en el estudio. El análisis de contenido de método fue aplicado en el análisis de los datos obtenidos. De los hallazgos se concluyó que la instrucción diferenciada mejoró las implicaciones de los estudiantes con la ciencia-tecnología-sociedad y el medio ambiente y desarrolló sus habilidades de proceso científico y por lo tanto contribuyó a los niveles de alfabetización científica de los estudiantes.

Palabras clave: instrucción diferenciada, el plan de estudios de la diferenciación, la alfabetización de la ciencia, la investigación cualitativa método

ISSN: 2014-6418
DOI: 10.17583/qre.2018.3383

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Science literacy is the primary and fundamental aim of the science education (Gregory & Hammerman, 2008). Science literacy can be expressed as addressing and embracing scientific and technological inventions and nature with the explanations of science as well as using the data and information obtained by scientific process skills in everyday life in a manner that ensures the quality of the human life (Liu, 2009). Science literacy was described as "becoming familiar with the natural world and recognizing both its diversity and unity, understanding the key concepts and principles of science, becoming aware of some important links interconnecting science, mathematics and technology. It also involves understanding that science, mathematics and technology are outputs of human efforts, recognizing the strengths and limitations that it brings to those areas, having scientific thinking capacity and using scientific knowledge and ways of scientific thinking for the sake of individual and social purposes (Turkish Council of Higher Education [YÖK], 1997). Similarly, science literacy is becoming aware of science concept, theory, rules and scientific research methods, understanding the interrelated effects of science, technology and society and their interrelationships, using the theoretical knowledge taught in schools to solve problems in everyday life, to explain the social problems related to science and in decision making, writing, reading and understanding scientific articles, magazines and books, participating in scientific discussions, expressing own ideas and interpreting what is said, having necessary knowledge and skills for impartial and critical thinking (Çepni, Ayvacı, & Bacanak, 2006). Changes emerged in science and technology and the new situations brought by these changes in the nature have shaped societies in the 21st century and educating science literate individuals is of utmost importance that countries are able to sustain international competition and protect nature as an inhabitable environment. Therefore countries benefit from theories and approaches that improve science literacy levels of individuals in their education systems. One of these approaches is the differentiated instruction implemented in this study.

Literature Review

Children have a sense of curiosity and discovery to explore the environment they live and the world. They also experience various learning experiences by interacting with their environments (National Research Council [NRC],

2012). Children who have the congenital efforts to perceive the world and the environment improve their scientific knowledge and skills with various research and studies besides the existing schemas (Mayer, 2004, NRC, 2007). For this reason, children are often called "innate scientists" (Cook, Goodman, & Schulz, 2011; Durbin, Pickett, & Powell, 2011). Skills such as observation, research, examination, exploration, discussion and deduction are very important skills in primary school science teaching and are the basis of the scientific thinking. It is argued that the effective science education in the primary school period increases curiosities of children when exploring the environment and ensures that they like science and at the same time forms the basis for secondary school science education (National Science Teachers Association [NSTA], 2009). Science is a knowledge that seeks to define and explain the world as well as a way of thinking and investigating based on experimental measures, logical thinking and continuous inquiry. Students learn and understand the natural world and they feel enthusiasm with its intellectual richness within the objectives of science education (Turkish Ministry of National Education [MEB], 2005). Proper learning environments and experiences should be formed to sustain children' congenital existing curiosities and improve their questioning skills (Sontay, Tutar, & Karamustafaoğlu, 2016).

Individual differences are seen in the educational environment. Gender and physical differences are just the visible part of the iceberg. Beneath the surface, students with different socio-economic levels, students from different family types, students with special needs, students with different interests and abilities, students with different cultural backgrounds, individual differences such as different languages, different learning profiles and different attitudes toward the school appear (Carter, 2011). Differentiated instruction is an approach based on differentiation of curriculums considering interests, abilities, needs, learning profiles and readiness of students due to individual differences (Anderson, 2007; Chapman & King, 2009; Gregory & Chapman, 2007; Joseph, Thomas, Simonette, & Ramsook, 2013; Landrum & McDuffie, 2010; Murawski & Hughes, 2009; Regan, 2009; Tomlinson, 2001; Tomlinson & McTighe, 2006; Tomlinson & Moon, 2013). In other words, differentiated instruction is a teaching philosophy aimed to ensure students realizing the best and effective/lasting learning by considering their readiness levels, interests and learning profiles (Tomlinson, 2005). Content, process, output, assessment

and learning environment are differentiated in the curriculums according to readiness levels, interests and learning profiles of students with differentiated instruction approach embracing this perception (Avcı & Yüksel, 2014; Dee, 2011; Fattig & Taylor, 2008; Levy, 2008; Muthomy & Mbugua, 2014; Tomlinson, 2001; Tomlinson, Brimijoin, & Narvaez, 2008; Tomlinson & McTighe, 2006; Tomlinson & Moon, 2013).

Differentiated instruction proposed by Tomlinson (2001) aims to differentiate teaching taking into account the three basic individual differences of interest, readiness level and learning profiles rather than a wide variety of individual differences of students. Differentiated instruction centralizes students and contributes to self-improvement and realization in the direction of individual characteristics of each student. Differentiated instruction also seeks more manageable and authentic methods to meet the different needs of students (O'Meara, 2010; Tomlinson, 2001). Thus, differentiated science instruction seeks ways to contribute to the development of spontaneously demonstrated scientific skills of children who are called "innate scientists" (Cook et al., 2011; Durbin et al., 2011).

There are quite few recent studies related to the efficiency of differentiated instruction in the literature. These studies reached a conclusion that differentiated instruction enhanced the academic achievement of the students (Aliakbaria & Haghighi, 2014; Boges, 2014; Durrett, 2010; Etienne, 2011; Gilbert, 2011; Joseph et al., 2013; Mulder, 2014; Osuafor & Okigbo, 2013). For instance, Durmus (2017) in his study stated that differentiated instruction applied in life science lessons enhanced the academic achievement and permanent learning. Besides, some of the studies found out that differentiated instruction increased students' motivation and positive attitudes towards the lessons (Baumgartner et al., 2003; Beecher & Sweeny, 2008; Boerger, 2005; Chen, 2007; Reis, McCoach, Little, Muller, & Kaniskan, 2011; Rojo, 2013; Walker, 2014; Zonnefeld, 2005) and also led the students enjoy their learning process (Alavinia & Farhady, 2012; Sondergeld & Schultz, 2008).

In addition, there are various studies which concluded that during the teaching and learning process with differentiated instruction the students experienced a sense of success, participated in cooperative tasks, took on responsibilities, showed metacognitive and problem solving skills and developed good peer relationships (Decovsky, 2012; Demir, 2013; Gault, 2009; Hackenberg, Creager, Eker, & Lee, 2016; Moyle, 2012; Munro,

2012; Samms, 2009; Sondergeld & Schultz, 2008; Westbrook, 2011). There are also some studies on the contribution of differentiated instruction to the self-efficacy of the students and teachers (Affholder, 2003; Dixon, Yssel, McConnell, & Hardin, 2014; Wan, 2015). However, though there are so many studies with differentiated instruction in various disciplines, the number of the studies in science course is very limited and there are also few studies on the effect of differentiated instruction of science literacy.

Purpose of the Study

Science literacy levels of students were identified as moderate in various studies carried out in Turkey (Saysal-Araz, 2013; Süren, 2008; Şentürk, 2017). Furthermore, in most European countries, there seems not to be specific support policy for students with low levels of achievement in science education. In major countries, nationwide programs were launched to overcome low achievement (Eurydice, 2011). For this reason it was aimed to contribute to the science literacy levels of students by embracing a different approach in this study. The main purpose of this study is to reveal contributions of the differentiated instruction implemented in the primary school 4th grade science course for the science literacy of students in direction of teachers and students interviews.

Method

Research Design

In this study, in which the contributions of differentiated instruction implemented in the primary school 4th grade science course into science literacy of students were examined, qualitative research methods were used. In the study, the qualitative research method was preferred as it contains characteristics such as allowing to reveal perceptions, participating role of the researcher, tuning into the genuine setting, flexibility in the research design, realizing inductive analysis with qualitative data (Maxwell, 2013; Merriam, 2009; Patton, 2002). The case study among the qualitative research designs was carried out for the purpose of the study. The case study involves in-depth analysis of one or more instances, environments, programs, social groups, society or other delimited systems .The case refers

to a holistic system. A teacher, a student or a newly implemented program and an approach can form the case. The case study is defined as an investigation of a current phenomenon in its authentic context (Stake, 1995; Yin, 2009). When the main aim of a study was to answer the question of "what", exploratory technique was preferred (Zainal, 2007). This study, which tried to answer the question of "what are the effects of differentiated instruction on the science literacy of the students who are enrolled in the 4th grade science course?" uses exploratory technique which is one of the case study techniques (Yin, 2009, 2014). Besides, in order to increase the validity and reliability of the study and thus to increase the strength of the study, observation, interview and student diaries were used to obtain qualitative data and also for triangulation (Creswell, 2009; Merriam, 2009; Yin, 2014).

The Study Group

The study was conducted with the 4th grade students (n=23) studying at the Kozabirlik Primary School affiliated with Ministry of National Education in Bilecik city center. Prior to the research, necessary correspondences carried out with the Bilecik Provincial Directorate of National Education and research permission was taken. In the study, the differentiated instruction approach proposed by Tomlinson (2001) was implemented in the primary school science course 4/A class during a total of twelve weeks.

The Intervention Process

In the study, the Differentiated Instruction proposed by Tomlinson (2001) was conducted in the 4/A class, the in a primary school during 4th grade science course between 14/02/2016 and 01/06/2016 for 12 weeks. At the end of these 12 weeks, students' and teachers' opinions were examined and the contribution of Differentiated Instruction to students' science literacy has been studied through case studies. The intervention procedure of the study is as follows. The teaching strategies and techniques applied in the intervention process of this study were composed of by utilizing various studies on differentiated instruction especially those of Tomlinson (from 1999 to 2016).

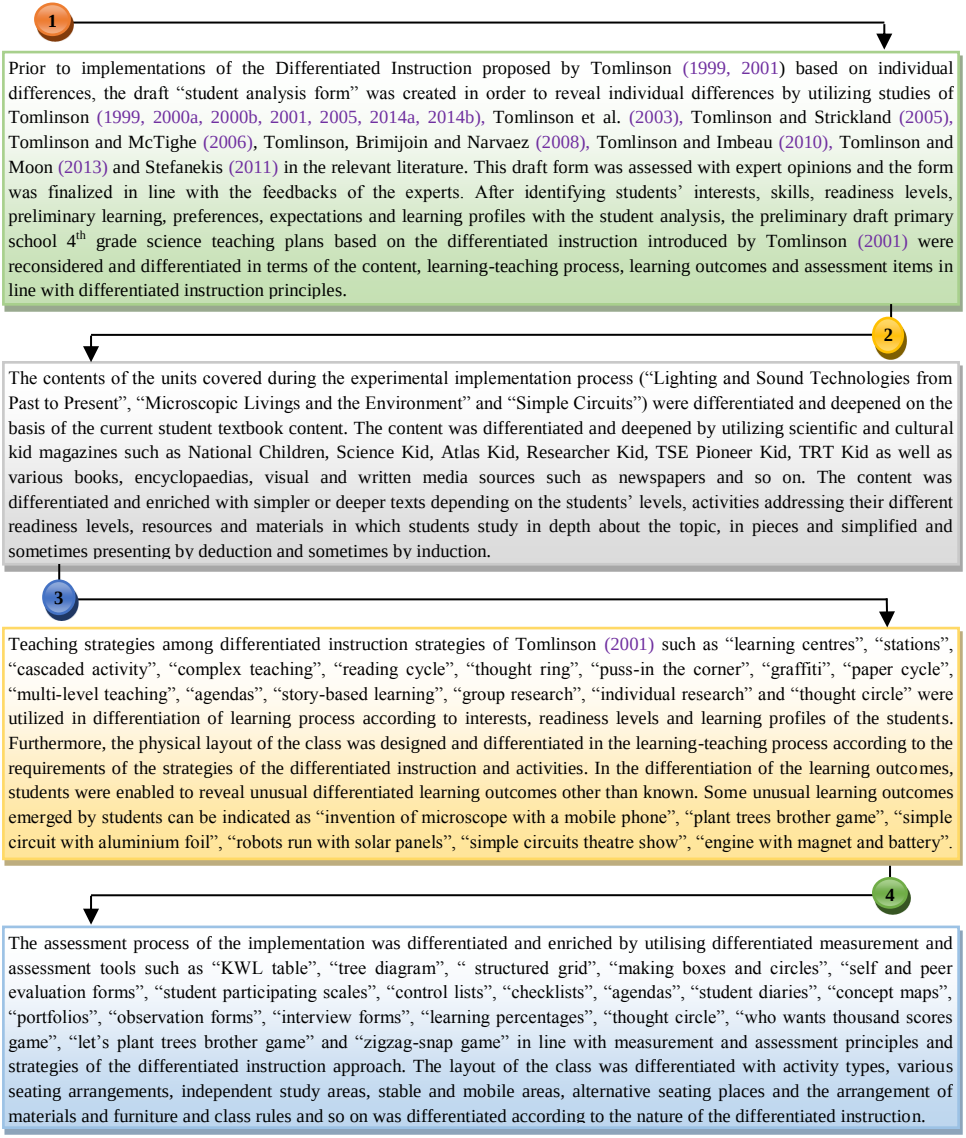

Figure 1. The Intervention Process

Data Collection Tools

Qualitative data were gathered through "observation forms", "interview forms" (students and teachers) and "student diaries". Explanatory information for interview, observation and student diary forms among qualitative data collection tools used in the research and efforts to ensure the validity and reliability of the data were described in brief in the following paragraphs.

Interview forms

The main qualitative data collection instrument used in the research is interviews with teachers and students. Interviews are beneficial to explore the story behind the participants' experiences. The main purpose of the interview is to gather in-depth information about a topic of interest or an anticipated question in the research (McNamara, 1999; Patton, 2002). In this study, a semi-structured interview technique was used. The researcher may add new questions and deepen interview questions in line with the subject flow during the interview in the semi-structured interview (Ekiz, 2003; Merriam, 2013). In this regard, semi-structured interview method was embraced in this study due to its flexibility for the researcher.

Interview forms appeared in the relevant literature were examined in order to demonstrate how differentiated instruction contributes to the science literacy levels of students (Amadio, 2014; Burkett, 2013; Koeze, 2007; Maddox, 2015; Robinson, Maldonado, & Whaley, 2014). Semi-structured interview forms were prepared considering the interview forms appeared in the relevant literature. In the study, it was considered that it would be significant to evaluate the opinions of both teachers and students in the scope of the research. The final interview form was obtained by taking their opinions of twelve experts composed of two academic members in Curriculum and Instruction Department, one in Science Education Department, one in Measurement and Evaluation Department, two were from Special Education Department, one is from in Language Department and additionally four classroom teachers.

Expert feedbacks were consulted in order to ensure the validity of the created interview forms. Appropriate changes, amendments and adding were included in the prepared forms in accordance with the feedback

received from the experts. The interview form was finalized with the feedbacks of the experts. Pilot tests of the interview forms were carried out and it was identified that both interview forms were operational. The interview form is composed of eleven questions for the students and twelve questions for the teachers. Following questions were asked during the interviews. For example, "how did differentiated instruction affect your relations with science?", "How did the lessons with differentiated instruction differed from the conventional ones?", "What do you think about how differentiated instruction affected the metacognitive skills and science literacy of the students?"

Observation form

Observation that is an important source of information in the qualitative data collection is one of the main supporters in clarifying the complexity of the social cases (Patton, 2002). In this regard, the observation method was considered to use in the diversification of the data within the scope of the study. Observation forms appeared in the relevant literature was examined to explore how differentiated instruction affects attitudes of students towards the course and contributes to their attitudes (Ayers, 2008; McGraw-Hill, 2010; Stronge Teacher Effectiveness Performance Evaluation System [STRONG], 2012; Subban & Round, 2015). Accordingly a semi-structured observation form was developed to identify how the differentiated 4th grade science curriculum contributes to science literacy levels of students considering observation forms appeared in the relevant literature. Expert opinions for the draft form were consulted in order to ensure the validity of this created observation form and the appropriate changes and amendments were included in the form in accordance with the feedback received from the experts. The pilot study of the prepared draft observation form was carried out and it was considered at the end of the pilot study that the form could be used for the experimental process, concluding that the draft observation form was operational. The observation form used in the study was composed of these questions like "Preparation for differentiated instruction, differentiated classroom environment, application of differentiated instruction in the class, differentiated learning activities, student-student relationship and students'

role in differentiated instruction, scientific process skills of the students and evaluation of differentiated instruction."

Student diary form

Student diaries that are suggested as a way to encourage students to evaluate their attitudes, behaviours, participations and learning in class are important data sources to reveal experiences, feelings and thoughts, perspectives, attitudes and behaviours of individuals (Glesne, 2012; Kaufeldt, 2010). In the study, student diaries were used in verification of the data. The student diary is a form so that students reflect on contributions of the differentiated instruction to their science literacy levels on a weekly basis. A draft diary form that students can use effectively and efficiently during the research process was created considering the student diaries used in various researches in the relevant literature (Baş, 2015; Ersözlü, 2008; Kurnaz, 2007). The draft student diary form was created in a semi-structured format. The created draft form was consulted with the expert opinions and appropriate changes and amendments were included in the relevant parts of the form. The students kept dairies by themselves on eight questions such as what they learnt in that week, what they liked and disliked in the lessons, and what they found interesting during the lessons in that week.

Validity and Reliability of Data

Studies are precious as long as the validity and reliability of the data are provided in the studies in which the qualitative research methods are embraced (Maxwell, 2013). In general, research is more or less mixed with bias but it is important to minimize this bias. Necessary measures were taken in order to minimize the bias in this research. In this context, the environment in which the study was conducted was also considered in the presentation of the findings in order to ensure the validity of the data. Findings were first described by quotations and then interpreted. The concepts that constituted the themes were assessed among themselves and with each other for their consistency and whether they constitute a meaningful whole were checked by opinions of an expert in the field. Data variation was provided to obtain detailed data and ensure data validity. On

the other hand, the notes taken were shown to both the students and the teachers using participation confirmation technique (Creswell, 2013; Merriam, 2009). Both the teacher and students were allowed to take out the bits they are not willing to include in the interviews. Expert opinions were consulted for the semi-structured interview and observation forms as well as student diary forms prior the practices. Interviews were recorded with permissions of the students and teachers and then transcribed. The researcher conducted interviews to ensure students with sincere and heartfelt responses.

Although it is difficult to ensure the reliability in qualitative research, various methods are suggested to ensure the reliability of the study. One of the measures that can be taken to increase the reliability of the research is asking people who have general idea regarding the research topic and who are specialized in qualitative research methods to examine the research in various dimensions (Yıldırım & Şimşek, 2011). The researcher and two academicians who have experiences in qualitative research and a teacher separately and independently coded data (interviews, observations and student diaries). Then these codes were compared with each other. For the reliability, the reliability calculation formula developed by Miles and Huberman (1994) [Reliability=Agreement/Agreement + Disagreement x100] was used for the codes formed by the researcher and other specialists. The percentage of agreement between three coders was calculated as %87. It is considered that reliability was ensured in terms of data analysis as it is sufficient to have 70% or more percentage of agreement (Miles & Huberman, 1994). Sharing the data obtained in qualitative research with those who are specialized in the related subject and receiving feedback from them increases the reliability of the research (Glesne, 2012). For this reason, the data obtained in the research and emerged themes were shared with two experts and feedback was received for the reliability of the research. Appropriate amendments were carried out in the necessary parts in accordance with feedbacks. . Within the context of the external validity, data creation, processing, analysis, interpretation and results processes were addressed clearly and in detail and the emerged data were directly presented without any interpretation with a descriptive approach in the context of internal validity.

Data Analysis

In the analysis of the data, the qualitative data gathered with the participation of the students in the experimental group were first classified separately by the researcher according to their dates and types (observation, interview, and diary) and transferred to the computer. A code list was created based on the relevant literature just before the data analysis process (Bogdan & Biklen, 2003; Creswell, 2013; Denzin & Lincoln, 2005; Merriam, 2009). In the processes of coding the qualitative data, teachers were coded with ORT, students were coded with ORN along with observation notes were coded with GN and student diaries were coded with OG.

In the analysis of the data, "content analysis" was used among the qualitative research data analysis methods. By content analysis method, it is aimed to reach in-depth and more themes than pre-determined themes identified according to the research results (Miles & Huberman, 1994). In this regard, the content analysis method was implemented in order to identify reflections of the differentiated instruction over the science literacy levels of students and reveal different aspects. The qualitative data obtained in the scope of the content analysis were coded by the researcher. The qualitative data set was continuously read by the researcher and the draft coding was made on the data. Draft coding was made several times in this way. Thus, the draft codes created several times were compared with each other to ensure the consistency of the codes. After the draft coding, the actual coding process from which the themes and sub-themes formed meaningful patterns was carried out (Auerbach & Silverstein, 2003).

Results

The main research question of the study which was formed in the direction of the aim of the research is as follows: "what are the contributions of the differentiated instruction into science literacy of the students?" Themes and sub-themes identified for the contributions of the differentiated instruction into science literacies of the students were indicated in Figure 2.

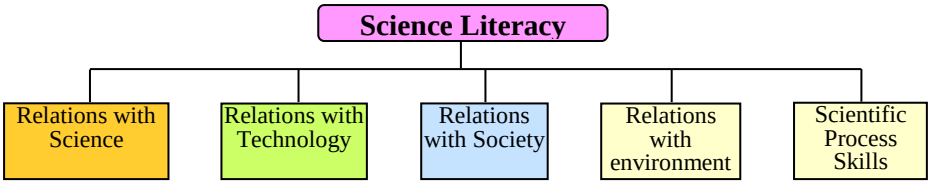

Figure 2. Themes and sub-themes for the contribution of differentiated instruction into science literacy

As seen in Figure 1, it appears that opinions of the participants for the contributions of the differentiated instruction into science literacy of the students were examined in sub-themes. The contribution of the differentiated instruction into science literacy emerged as "relations with science", "relations with technology", "relations with the society", "relations with the environment", "scientific process skills". Besides, in order to identify the opinions of the participants (students and teachers) about the contribution of differentiated instruction to the teaching-learning process and to describe the case in a general manner, the opinions and answers obtained from the interviews and student diaries, the qualitative data code and percentages and frequencies of the qualitative data are given in brief in Table 1.

Table 1
The Opinions of the Participants on the Contribtion of Differentiated Instruction to Science Literacy

Theme	Sub-themes	Quotations	Qualitative Data Codes[1]	% and f [2]			
				f_{ORN}	%	f_{OG}	%
The Theme: Science Literacy	Relations with Science	*We did experiments and many activities in science lessons. Since we did different activities, science course began to get my interest more. We began to look forward to science lessons. We had joyful times in science lessons* [ORN_1]. *Science lesson has become very important for me. In the past, I was not interested in science lesson. The things we did got me to love science course. Now, I love scientific subjects more. I want to be a scientist* [OG_4].	ORT, ORN_1, ORN_3, ORN_4, ORN_8, ORN_{10}, ORN_{12}, ORN_{13}, ORN_{16}, ORN_{18}, ORN_{22}, ORN_{23}, OG_2, OG_4, OG_{11}, OG_{15}, OG_{20}, GN	11	48	5	22
	Relations with Technology	*We tried to use technological tools in the lessons. We used them in our every lesson. We understood the lessons better with the technological tools and also we enjoyed the lessons* [ORN_{15}]. *We examined ligttening and sound technologies from past to present times. Our teacher brought old tools into the classroom. We touched and examined them. My interest in these tools increased* [OG_5].	ORT, ORN_2, ORN_5, ORN_6, ORN_7, ORN_9, ORN_{11}, ORN_{14}, ORN_{15}, ORN_{17}, ORN_{19}, ORN_{20}, OG_1, OG_5, OG_9, OG_{12}, OG_{23}, GN	11	48	5	22
	Relations with Society	*We get int touch with people we do not know. We ask them our questions. We write down the answers. Once we made voice recording. We also talked to the people in our school. We talked about the air pollution with them* [ORN_{16}]. *I always told my parents what we had done in the lessons. We did very different activities every week. I told my parents everything with a great ambition that night* [OG_6].	ORT, ORN_1, ORN_3, ORN_5, ORN_7, ORN_8, ORN_{11}, ORN_{13}, ORN_{14}, ORN_{16}, ORN_{18}, ORN_{21}, OG_6, OG_8, OG_{16}, OG_{18}, OG_{20}, GN	11	48	5	22

(continues)

Table 1
The Opinions of the Participants on the Contribtion of Differentiated Instruction to Science Literacy (continuation)

Theme	Sub-themes	Quotations	Qualitative Data Codes[1]	% and *f*[2]			
				f_{ORN}	%	f_{OG}	%
The Theme: Science Literacy	Relations with environment	*We learnt that only the rubbish does not pollute the environment. We try to not make noise. We do not pollute our environment* [ORN_6]. *I learnt that we should put the wastes into the recycle bins. We should put the waste sucs as glass, paper, plastic and battery into the recycle bins. Now I collect such wastes. Then I throw them into the bins* [OG_3].	ORT, ORN_2, ORN_6, ORN_9, ORN_{10}, ORN_{12}, ORN_{16}, ORN_{17}, ORN_{19}, ORN_{20}, ORN_{23}, OG_2, OG_3, OG_6, OG_9, OG_{14}, OG_{17}, GN	10	43	6	26
	Scientific Process Skills	*We decided on problems with the subjects. For instance, harmful microscopic creatures can be a problem for us. We held studies on how we can protect ourselves from the microscopic creatures. And we shared the results of our studies with our friends* [ORN_1]. *We did studies as scientists do. We made observations in order to verify our hypotheses, we did interviews and experiments. We all became scientists in the lessons* [OG_7].	ORT, ORN_1, ORN_2, ORN_3, ORN_4, ORN_5, ORN_8, ORN_{11}, ORN_{13}, ORN_{14}, ORN_{15}, ORN_{16}, ORN_{17}, ORN_{18}, ORN_{20}, ORN_{21}, ORN_{22}, ORN_{23}, OG_3, OG_7, OG_{10}, OG_{13}, OG_{14}, OG_{17}, OG_{19}, OG_{21}, OG_{22}, GN	17	74	7	30

The first contribution into science literacy was the sub-theme of "relations with science". The students expressed that they are more interested in science with the differentiated instruction, they learned while they had fun, they sought to use the science knowledge they acquired in everyday life.

> *I was not so interested in before. Now, science is more interesting. Because courses are becoming something we like. We are having a lot of fun. We enjoy and learn* [ORN_3].
>
> *I came to school even the day I was sick. I do not want to miss this course. I began to like science lessons very much. I read science magazines, I learn new things. I share the things I learned with my friends. I want to be a scientist* [ORN_4].
>
> *I did some research at home. Sometimes I went to the library and searched through the books there. I read from the magazines. I watched videos from the internet. I learned new information. I've never done this kind of research before. I am more interested in science lessons now* [OG_{20}].
>
> *I learnt very different information in the lessons. We did very different activities and played games. I thought about where and how I can use what I learnt in the lessons. We can use such knowledge in other lessons* [OG_{15}].
>
> *Science lessons with differentiated instruction became influential for me and for my students as we experienced a very magnificent process. I am happy and my students are happy. These studies increased the curiosity of my students in science lessons. They tried to satisfy their curiosity by using different and interesting sources. They shared what they learnt with me, their friends and parents. They did not forget what they learnt* [ORT].

Classroom teacher [ORT] pointed out that the science course with differentiated instruction became more interesting for both himself and his students, curiosities of the students regarding the science course increased with the commencement of the process, they became to get more interested in science topics, they sought to address their curiosities with different and interesting sources and they shared the information they learned with others. It was pointed out in the observation notes [GN] that the students were more interested in science through differentiated teaching process, enjoyed science with enthusiasm, and were eager for the next science lessons, pursuing resources in the field of science, sharing through social

media, sharing knowledge, experience and experiences in the science course with others.

The second sub-theme of the contribution of differentiated instruction practices to science literacy is "relations with technology" sub-theme. The participants expressed that they were more interested in technology with differentiated instruction, they made more use of technological tools and materials in lessons and everyday life, they also created technological tools during the process.

> *Our teacher brought Walkman, cd, tape-recorder, pen radio, audio recorder, cassette to the class. We examined audio tools from past to today. We made a voice recording at the class. We recorded the voice of each of our friends. Then we listened to our voice. We learned how to make a voice recording* [ORN_9].

> *We made robots at the class. We made our own robots. Our robots were working with solar energy. We enjoyed while we made our robots. We were very happy when our robots functioned* [ORN_{14}].

> *I shared the activities that we carried out at the school on Facebook. My friends liked them. It was good to announce our work to other people. I benefited from my cell phone for this* [OG_5].

> *During the whole process, it has been observed that the students were interested in technological tools and utilized them. The teacher was observed to bring technological tools into the classroom for each unit and the students were observed to touch, observe and use them any time and they were also pbserved to produce new technologies in the lessons* [GN].

In the researcher observation records [GN] and teacher interview records [ORT], it appeared that technological tools and materials were benefited in the differentiated instruction process, interests and curiosities of the students increased towards technological tools and equipment and students introduces new technologies by examining old and new technological tools. Furthermore, it was stated that more utilization of technological tools and equipment increased further students' relations with technology.

The third sub-theme of the contribution of differentiated instruction into science literacy is the "relations with the society" sub-theme. The participants stated that they carryout out various activities by interacting with the society through the studies with differentiated instruction.

> *I shared what I learnt with my father, mother and siblings. They also learnt new knowledge. We did the activities at home again. My sibling learnt new things, as well. Sometimes I also told quests and my relatives what I learnt* [ORN_{11}].
>
> *It was annoying that the neighborhood was dirty. One day we started collecting trashes around taking our bags. We set an example for others. There were those who helped us* [ORN_{21}].
>
> *One day we wanted to inform people about the pollution. We prepared a poster. We travelled around by taking them on lunch break. They congratulated us. We had a very nice activity* [OG_{18}].
>
> *It has been observed that the students talked to different people about the activities and studies they did on their own and that they presented and shared what they obtained with the class* [GN].

When observation records [GN] were examined, notes appeared about students' relations with the society. In these notes, it seemed that the students interacted with the society for various reasons and they presented the information and experiences they achieved at the end of this interaction in the class. The teacher of the experimental group [ORT] stated that their students undertook the role of social awareness with some studies.

> *The students have done a lot of research. In particular, they communicated with people about the issues that concern the society, took their opinions and presented in the classroom. They carried out various activities to inform people and raise their awareness. Of course, they first tried to make their families aware of and then other people. Important feedbacks about this were received from their parents* [ORT].

The fourth sub-theme of the contribution of differentiated instruction into science literacy is the "relations with the environment" sub-theme. The

students stated that their environmental awareness improved further, they paid more attention to the environment and sought ways in order to improve the environment.

> *We had the "not trash, waste" activity with the Karagöz-Hacivat [a national puppet show] shadow play. There were waste materials in the balloons. We blew up the balloons. We completed the activity by throwing waste materials into waste boxes* [ORN_{20}].

> *We planted trees in the garden of our school in an activity about the environment. Everybody planted a sapling. Our school garden became even more beautiful* [ORN_{19}].

> *Activities on the environment were carried out in each subject discussed in the differentiated instruction process. Environmental awareness of the students improved within these activities. They became further aware towards the environment and made efforts to keep the environment clean and protect it. They carried out activities. They developed projects. Sometimes parents participated. We conducted the activities together* [ORT].

> *It has been observed that the students have become more sensitive about the environment and that they tried to protect their environment from pollution. It has also been observed that the students did various activities on environment protection cooperatively* [GN].

The fifth sub-theme of the contribution of differentiated instruction into science literacy is "scientific process skills" sub-theme. According to the results, it was revealed that the students used the different knowledge obtained from investigations and research on various topics throughout the process.

> *We hypothesized when we were investigating a topic. Then we were investigating whether our hypothesis was correct. We were confirming our hypothesis based on our research. We were hypothesizing again if our hypothesis was wrong* [ORN_{8}].

> *We had various experiments at the class. We repeated these experiments at home. We showed out experiments to our families. We learned by doing and seeing* [ORN_3].
>
> *We had experiments with solar panels. We investigated whether we could generate electricity from the sun. We eventually run the circuit with solar panels. We learned new things* [OG_{13}].
>
> *We had scientific studies in class. We did research, made observations, made examinations, and had experiments. We worked like a scientist. We made observations to confirm our hypothesis, had interviews and experiments. I felt like a scientist myself. We had inventions like them* [OG_{17}].
>
> *The fact that the development of students' scientific process skills is an important part of differentiated instruction. For this reason, we had many different activities to improve such skills. During these activities, I guided and helped my students when necessary. I tried to help them by providing resources and tools which they will not be able to reach by themselves* [ORT].
>
> *It has been observed that the students did researches on various topics and that they made a plan before they began to do their researches and they followed their plan. They were also observed to exhibit scientific studies by developing hypotheses, doing observations, investigations, experiments, interpretations and developing suggestions* [GN].

In the researcher observation records [GN], it was stated that students carried out studies involving scientific process skills such as research, examination, observation, interview, measurement, comparison, hypothesizing, data collection, finding the results, developing suggestions, similar to opinions of above students. The classroom teacher [ORT] stated that students were a part of the development of scientific process skills, various efforts were made to improve the scientific process skills and he assisted the students in various ways, tried to provide the necessary guidance to them and thus contributed to improve the scientific process skills of the students.

Discussion and Conclusion

Developed countries attach importance to educate their citizens with science literacy in order to adapt to rapid progress in science and technology and obtain qualified manpower (Çepni et al., 2006). In this study in which differentiated instruction was used, it was identified that the students improved their attitudes towards the science course and thus took steps to become science literate carrying out efforts such as learning science concepts, theory and scientific research methods, reading magazines, books and journals about science, participating, observing, exploring and evaluating in science activities. Therefore, it can be argued that the applied practices contributed to the students regarding expectation of becoming science literate in the 21th century. In the differentiated instruction process, it can be regarded as an usual case that the students improved their attitudes towards the course as a result of the efforts made such as taking science education according to their interests, readiness levels, and learning profiles, stimulating their curiosity and exploration senses, having different learning experiences that they have never met before, encountering with different sources and materials, undertaking learning responsibilities, preparing environments to encourage students to think and investigate, and embracing alternative assessment types.

In this qualitative study, the first sub-theme of the contribution of differentiated instruction into science literacy was the "relations with science" sub-theme. When the findings were examined, it appeared that interests and curiosities of the students towards science increased with differentiated instruction and they were more interested in science subjects. It can be said that this interest and curiosity emerged for science encouraged them to conduct various research about these subjects, improved their interactions with science and this eventually improved their science literacy levels. In the study, it was seen that the technological relations of the students emerged as an important feature in the differentiated instruction process. The students expressed that they were more interested in technology, benefited more from technological tools and equipment in the lessons and everyday life, and created technological tools in the process with differentiated instruction. The students stated that they used the technological tools individually in unnecessary forms except for the purpose in the previous processes, they usually played games with these

tools, but they used technological tools more useful occasions with differentiated instruction. It appeared from the student interviews that the differentiated instruction practices encouraged students to use technology properly. The students stated that they benefited from other technological tools and equipment in their homes. The students expressed that they usually had their classes with technological tools and equipment during the differentiated instruction process, these sorts of efforts increased their curiosities towards technological tools and equipment, directed their interests towards technological tools and equipment and eventually they attempted to examine technological tools and equipment. Furthermore, the students stated that they also created small technological tools in the differentiated science class and were willing to create greater technological tools and equipment in the coming years. The use of technology in differentiated instruction is vital. In particular, educators who embrace and use technology can easily differentiate the teaching process according to their interests by addressing their interest. In this way, teachers can transform the process into a more interesting and pleasant form with technology making learning easy and permanent. Technological tools are helpful in increasing the effectiveness of differentiated instruction. For this reason, all technological possibilities in differentiated instruction ought to be utilized at the maximum level (Hamill, 2010; Tomlinson, 2001). It was seen that technological tools were utilized at the highest level in the differentiated instruction process in this study.

When the relevant literature was reviewed, it appeared that technological tools increased the effectiveness of differentiated instruction (Olsen, 2007; Smith & Throne, 2009; Stanford, Crowe, & Flice, 2010; Wahl & Duffield, 2005). Although there seems to be studies on the use of technological tools in differentiated instruction in the literature, no qualitative studies that truly reveal the extent to which the relationships between technology and science literacy of the student appeared. There is a need for research in this regard in order to be able to identify the extent to which the relationships of students with technology in the differentiated instruction process. It is considered that research to be conducted in this regard would have a great importance in clarifying the relationships of the students with the technology in the differentiated instruction process.

Students are expected to perceive the nature of science along with interactions with the environment and society and use the gained

knowledge, skills and perceptions to solve the problem in the science class. It is vital for students to learn associating science-related knowledge with outside of the school due to rapid developments in order to use science in all aspects of life. The American National Science Teachers Association [NSTA] describes the social dimension of science literacy refers to individuals who "can respond to needs of the society with scientific and technological accumulation, solve social problems, take responsibilities to involve in personal and social activities, analyze the interaction among science, technology and society" (Yager, 1993, p.145). For this reason, the relationships of students with the society in science education are vital. In this research, it can be stated that the findings on the relationships of students with the society in the differentiated instruction process emerged in the relations with the society sub-theme are noteworthy.

In the study, it appeared that the students shared the knowledge and experiences gained in science with the society, informed the society about the innovations in this area and introduced learning outcomes to the society. In this way, it can be stated that the students made efforts to increase their science literacy levels by improving their relations with the society. While various studies exploring the effectiveness of differentiated instruction in science appeared in the literature, no qualitative researches that indicated truly the relations with the society dimension appeared in the studies of students' science literacy levels. In this respect, there is a need for research in this area in order to be able to identify the extent to which relationships of students with society in the differentiated instruction process. It is considered that the research to be conducted in this regard would have a great importance in clarifying the relations of students with the society in the differentiated instruction process. Despite similar studies do not appear in this regard, it is natural and usual that students' relations improved with the society as outcomes of efforts such as ensuring students to interact with the society directing various research in the process, introducing learning outcomes to the society, and preparing environments to be able to share the gained knowledge and experiences with the society. As a result, it can be said that differentiated instruction implemented in this study improved relationships of the students with the society directing them to society-related practices and this improved their academic achievements and attitudes towards the course.

According to research results, it was observed that the environmental relationships of the students emerged as an important feature in the differentiated instruction process. The students stated that their awareness towards the environment in the differentiated instruction process improved and they considered the environment and involved in various efforts to improve the environment. Furthermore, it was seen in the findings that recycling awareness were formed to protect the environment. The students expressed that they took various actions both in the classroom and school and outside of the school environment to protect and improve the environment. As a result, it was observed that the students developed their relationships with the environment in the differentiated instruction process and they considered the environment/nature, made efforts keep the environment clean and took some actions to protect/improve the environment/nature. One of the objectives of the science education is to ensure students to explore the environment and the world, raise awareness toward incidences or exchanges that occur in their surroundings, form awareness of protecting the environment/nature as an inhabitable environment (Can & Şahin, 2015).

Individuals are expected to internalize the nature of science and explain its relation with the society and the environment and use this understanding and gained skills to solve contemporary problems (MEB, 2005). Being unconcerned with the environment causes environmental problems and damage people's lives and living resources. In this regard, the solutions of environmental problems can be provided not only with rehabilitating the environment but also developing a consciousness that protects the environment (Yağlıkara, 2006). In the research, it was considered that the students developed interests and awareness towards the environment, involved in various actions to explore and examine the environment and made efforts to protect and improve the environment with the differentiated instruction. Therefore, it can be said that the students formed consciousness towards the environment with more interaction with the environment. Furthermore, it was observed that this gained environmental consciousness transformed into behavior.

When the reform movements in the educational environments of different countries were examined, it was emphasized that all individuals in the society should be educated as science literate The underlying reason for this emphasis is that science is considered not only as a way of identifying

the physical and biological world but also a way of inquiry-based research and thinking based on experimental measures and logical thinking (MEB, 2005). The last sub-theme of contributions of the differentiated curriculum into science literacies of students was "scientific process skills". The findings were observed regarding students' scientific process skills in the differentiated instruction process. The students stated that they were involved in the research process to solve the problems identified within the scope of topics and they prepared the necessary plans prior to the investigation. In the interviews, it was observed that the students carried out practices such as observations, interviews, explorations, measurements, comparisons, classifications, hypothesizing, data collection, analysis and interpretations within the scope of the scientific process skills. In the study, it was revealed that the students investigated various issues in the process and used the information gained in the investigations and research. Furthermore, it was observed that the students classified and compared the data they gained in the research. In addition, it was seen that the students took actions such as hypothesizing, identifying the research method to text the hypothesis, obtaining the findings of the research with the determined method, interpreting/discussing the obtained findings and drawing conclusions and developing suggestions in accordance with scientific research methods. In the findings, it was observed that students improved basic scientific process skills (observations, classifications, measurements, prediction, deduction and interaction) as well as advanced scientific process skills (hypothesizing, experimenting, measuring, comparing, researching-exploring, formulating, interpreting the data and graphing).

It was concluded that the differentiated instruction is effective in improving scientific process skills of the students in the research. It can be said that the differentiated instruction stimulated students' existing senses of curiosity and exploring in accordance with the interests, readiness levels and learning profiles of the students and directed them in their interest areas individually or in groups. Myers (2004) described scientific process skills as a skill of planning, conducting and interpreting findings of a study by observing, comparing, classifying, measuring, experimenting and predicting. In the context of the mentioned explanations, the students took responsibilities and demonstrated basic and high level scientific process skills to solve the problems during the process. When the relevant literature was reviewed, various studies that revealed contributions of differentiated

instruction into scientific process of the students appeared. For instance, Çalıkoğlu (2014) and Kaplan (2016) pointed out in their study in which the effects of the differentiated science instruction into scientific process skills were examined that differentiated instruction improved scientific process skills of students by identifying significance difference between scientific process skills posttest scores of the experimental group students with differentiated instruction and scientific process skills posttest scores of the control group. These results are consistent with the findings of this study.

The findings obtained from the researches indicate that differentiated instruction practices contribute to scientific process skills of students. However, these studies were conducted mainly in the quantitative forms and qualitative studies to be able to compare the data coming from the different sources are limited to explore development of students' scientific process skills. In this direction, it can be said that quantitative and qualitative studies are highly needed in identifying effects of differentiated instruction into development of scientific process skills of the students. It may be considered that the further studies can have great importance in clarifying how scientific process skills develop in the differentiated instruction process. In conclusion, it may be reported that students' science-technology-environment relations and scientific process skills improved with differentiated instruction implemented in the primary school 4th grade science course in this study and in this way the implemented differentiated instruction contributed to their science literacy levels as well as national and international competencies and achievements. While few people against the value or the proposition of scientific literacy, no ultimate consensus has been reached on its definition (Roberts, 2007). However, when the definitions in the literature are examined, it is seen that there are various dimensions of science literacy. These dimensions are; the nature of science, the knowledge of key science concepts, the scientific process skills, science-technology-society-environment interactions, scientific and technical psychomotor skills, scientific values, science related attitudes and behaviors (Kavak, Tufan, & Demirelli, 2006; Millar, 2008). In the differentiated learning-teaching process put into practice in this study, students were seen to develop relations in terms of science, technology, society and the environment and thus make significant progress in the path of science literacy.

Suggestions

Whilst various studies appear regarding the effect of differentiated instruction in science, no qualitative research in which relations with science-technology-society and the environment and scientific process skills in science literacy of students were truly revealed appeared. In addition, quantitative studies that examine the effect of differentiated instruction in science literacy of students are also limited. In this regard, further studies are needed in order to be able to identify and explain the relations of students with science-technology-society and the environment and scientific process skills in the differentiated instruction process. It is considered that further studies within this scope would have a great importance in clarifying the contributions of differentiated instruction into science literacies of students.

This present study examined the contribution of differentiated instruction implemented in the primary school 4th grade Science course into science literacy levels of students. Similar studies can be carried out in different classes (Turkish, Mathematics, Social studies, English, Sports, Arts, Music and so on.) at the same teaching stage and considering teaching stages (pre-school, primary school, high school and higher education). In particular, considering there are limited studies related to differentiated instruction and usually conducted in certain courses at certain teaching stage, it would be beneficial to carry out studies on differentiated instruction in various disciplines at different teaching stages. Furthermore, studies on differentiated instruction were generally conducted with quantitative research methods and it can be stated that further studies with qualitative research methods are highly required. Therefore researchers can carry out various studies on differentiated instruction by qualitative or mixed methods.

Acknowledgment

This article was produced from the dissertation study entitled "Investigation of the effectiveness of differentiated instruction program applied in primary school" by the first author under the consultation of the second author. The dissertation is available in Turkish at http://www.yoktez.gov.tr/

In this research process, I would like to thank Prof. Dr. Hakan SARI, my precious teacher, who provided me with all kinds of support with his opinions and suggestions and I would like to thank for all kinds of support the teachers and managers of Kozabirlik primary school (Bilecik/Turkey) where the research has been carried. Dr. Cihad ŞENTÜRK

Notes

[1] ORT: Teacher interview transcription
OG: Student diary transcription (student diary record)
ORN: Student interview transcription
GN: Investigator observation transcription
[2] Since ORT and GN are individuals, % and f values are not given in the table.

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