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Exploring how future scientists are disciplining their mind

Özge Can Aran[1] · Nuray Senemoğlu[1]

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Abstract
This study aims to reveal gifted students' ways of disciplined thinking in science course. 10 students who were gifted in science were interviewed in accordance with the purpose of this paper. The data collected through the interviews were put to descriptive analysis. The results demonstrated that most of the students gifted in science made connections between the knowledge they had learned in science classes and life at home in relation to the theme of setting up connections with real-world, that they learnt the knowledge related to thinking in depth by researching on the internet, that they made connections between what they had learned in science classes and mathematics course in relation to the theme of setting up interdisciplinary ties, that they made statements about making experiments and controlling the variables in relation to the theme of thinking like a scientist and that they made statements about liking the process of learning in relation to the theme of getting motivated to live in a disciplined way. The findings obtained are thought to shed light on taking precautions to lead each student into disciplined thinking.

Keywords Disciplined mind · Gifted · Secondary school · Science course

Literature Review

Educators are aware of the fact that many students including the gifted cannot reveal their own potential. There can be several reasons for it. Yet, one of the most important reasons is that the education offered and assessment made at schools cannot make students learn or make them show their learning effectively (Sternberg, Jarvin, & Grig, 2011). In this context, it is important to search for answers to the questions "how can teacher uncover students' potentials?", "how can we turn students into well qualified scientists, artists and lawyers?" and to Howard Gardner's (2008) question "how can we discipline the mind?" Gardner (2008) answers the final question-which also contains the answers to the first two questions as in the following:

> Interest and capabilities should be determined ("you have the capability to be a scientist, a historian, a literary critic, a lawyer, an engineer or a manager"), models for ways of thinking should be set (" we prove such a theorem in this way"), certain important tasks should be completed successfully ("it is a good analysis of sonata 23; let us see whether you will be able to make a similar interpretation of sonata 36"), beneficial feedback should be given in time in relation to earlier efforts made for disciplined thinking ("you did well in analysing the data but think about the details of the control conditions before starting the experimenting the next time") and sequential steps should be taken in the way followed in specialising in a discipline ("you have learnt to write a good introduction to a story, your next task is to put the paragraphs into order. Thus, important points will remain even if the story is left unfinished") to raise individuals as experts in disciplines.

It is clear that Howard Gardner argues that the first stage in raising individuals who think in disciplined way is to

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✉ Özge Can Aran
ozgecann06@gmail.com

[1] Hacettepe University, Curriculum and Instruction, Ankara, Turkey

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determine interest and capabilities. So, what should be done to transform individuals who have interest in a discipline into individuals who think in disciplined way? It is apparent that disciplined mind, which Gardner (2008) thinks necessary to achieve success in the world of the future and which he stresses as one of the five minds, has several features. The features that disciplined mind-which Gardner (2008) stresses- contains also began to attract present day researchers' attention. The features of disciplined mind which Gardner describes in general and explains by giving examples from various disciplines is divided into groups by Can Aran (2014) for the first time. The properties that individuals with disciplined thinking-which Gardner refers to- are expected to display are divided into such themes as setting up connections with real-world, in-depth learning, setting up interdisciplinary connections, thinking like a scientist and getting motivated to live in a disciplined way in the abovementioned categorisation (See Table 1 in the research of Can Aran and Senemoğlu (2021)). Miller (2011) reached similar results in the heuristics code list he created regarding the disciplined mind in a different field. In this context, while *individuals who make connections with real-world* are expected to have conscious and in-depth views on comments about current events, on new scientific discoveries and technological advances and on new laws concerning the environment- that is to say, to understand the world and to learn the knowledge meaningfully (Bruner, 2009; Dewey, 2010; Gardner, 2008; Glasersfeld, 1981); *individuals who learn in-depth* are expected to get the essence of a subject instead of memorising the subject, to have deeper understanding, to make continuous efforts to acquire new skills and to be able to explain the knowledge with which they were not familiar before in scientific principles (Biggs, 1987; Cherif et al., 2010; Gardner, 2008; Entwistle, 2000; Entwistle, 2009; Light & Micari, 2013). *Individuals who set up interdisciplinary connections* on the other hand, are expected to become skilled in more than one discipline, not to confuse knowledge about a discipline with knowledge about another discipline while becoming skilled in more than one discipline, to use the knowledge when appropriate, to make a synthesis in an interdisciplinary perspective and to use the synthesis in an unusual way (Bybee et al., 2008; Gardner, 2008; Venville & Dawson, 2004). *Individuals who think like scientists* are expected to put their scientific process skills into practice and to try to understand the world thus (for instance, scientists observe the world, suggest temporary classifications, concepts and theories, they design experiments to test the temporary theories, they revise their theories in the light of their findings. Then they make more observations, re-organise their classifications and they acquire new knowledge to design experiments), to know the difficulty of revealing the causes of events, not to confuse causes with effects, to avoid simple and one-sided explanations, to accept that knowledge does not have certainty and that scientific methods and theories can change over time and to know the ways of reaching reliable resources (Abruscato, 2000; Bybee et al., 2008; Bybee, 2006; Chiappetta & Koballa, 2006; Gardner, 2008; Zimmerman, 2007). *Individuals who are motivated to live in a disciplined way* have such characteristics as enjoying learning about the world in general and turning learning into a passion, devoting themselves to their work, improving themselves continuously and keeping learning after formal education, working continuously to improve their knowledge and skills in a discipline (for example, doing exercises regularly in a discipline or being concerned with science laboratory experiments patiently), having desire to gain extra knowledge, to learn more deeply and to show the knowledge to themselves and to others after understanding a concept (Chiappetta & Koballa, 2006; Deboer, 2006; Entwistle, 2009; Gardner, 2008).

It is thought that cultivating individuals who have in-depth knowledge in their field of interest, who can use this knowledge to facilitate life, who have made learning a lifestyle, and who think in a disciplined way will be a great gain for societies. It is thought that cultivating these individuals especially in the field of science will carry societies to advanced levels in science and technology (Can Aran and Senemoğlu, 2014). At this point, it is important to raise gifted students, who have the potential to carry the society above the modern civilization level (Altun & Serin, 2019; Watters & Diezmann, 2003), as disciplined thinking individuals from an early age (Diaz, 1998; Sumida, 2013). At the same time, it is very important to develop disciplined thinking skills in gifted students who are ready to live with uncertainty (Kahyaoğlu & Pesen, 2013) in order to cope with the problems that affect the world, such as an epidemic that suddenly appears in today's VUCA world (Senemoğlu, 2011), which is volatile, complex, uncertain and ambiguous. Sumida (2013) and Tatarinceva et al. (2018) et al. stated in their researches that there was a need for effective education models to develop the giftedness potential of students and to effectively integrate them into society. At the same time, the model to be developed for gifted students should be used as an educational model that can improve the general literacy of the public as well as training professionals such as scientists and engineers. The educational model for gifted should also be in a way that contributes to the cultivation of emotionally and physically healthy citizens and the formation of a peaceful, sound society rather than being used merely as a means of social choice for the elite or a tool for social exploitation of intelligence. At this point, it is thought that any education model to be prepared for the development of disciplined mind will contribute to the formation of such a society.

Considering the fact that the first stage of developing disciplined mind is to determine the interest and capabilities of individuals in a discipline (Gardner, 2008), determining how ways of disciplined thinking emerges in individuals who are

described as gifted according to their interest and capabilities (Sumida, 2013; Taber, 2007) is thought to be important- because the extent to which enriched environment applications offered to gifted individuals work in preparing those individuals to the world of the future will also be demonstrated in this way. Considering that there is a mismatch between the potential or abilities of many gifted students and their school success, their needs for teaching programs and teachers that will meet their educational needs and support their thinking gain more importance (Rayneri, Gerber, & Wiley, 2006). Considering that not only gifted students but also students of all skill levels lag behind individuals in many developed countries (PISA, 2019; Rayneri, Gerber, & Wiley, 2006), the detection and treatment of students' deficiencies is both a national and an international problem. Based on such a finding to be obtained, contributions will also be made to educators in terms of activities to be done for the development of enriched environment applications which are expected to be offered to both gifted and ungifted individuals (Watters and Diezmann, 2003). Setting out from this idea, this current study aims to determine the indicators of disciplined mind in individuals who are described as gifted in science according to their interests and capabilities. Firstly, the literature on the characteristics of gifted individuals was reviewed to reveal gifted individuals' ways of thinking more clearly and to discuss the findings within the scope of the concept of gifted.

The Concept of Gifted

It is remarkable on examining the traditional perspective of the concept of gifted that it is academic oriented (Sternberg et al., 2011). The description of gifted previously contained those who displayed top 1% achievement in the capabilities of general intelligence in Stanford-Binet or in similar tests. Later, the description was thought to be inadequate since it laid emphasis more on cognitive competence and since it ignored such areas as art, psychomotor, creativity and leadership (Renzulli, 2002). Because it was emphasised that what was important for individuals to achieve success in life was to adapt into rapidly changing environments, to work as a part of a team, to resolve conflicts and to have skills to protect their health as much as possible. The academic skills that students gain at school are also valuable in reading a prescription or a label on a product in a shopping mall. However, academic skills should be considered as only a part of the thing that leads individuals to develop their highly gifted potential (Sternberg et al., 2011). In this context, many researchers such as Renzulli, Sternberg and Zhang, Csikszentmihalyi and Gardner say that several different abilities in addition to IQ are required to be able to describe individuals as gifted. In other words, it would be inappropriate to label individuals as gifted according to the results of an IQ test or of an achievement test (Sternberg et al., 2011). Behaviours of giftedness can be described with ability above average, fulfilling high level tasks and with high level creativity. Howard Gardner also describes intelligence by emphasising problem solving and creativity on the basis of up to date approaches. Thus, gifted individuals were described as people who were intellectual, creative, who had high performance in artistic areas, who displayed unexpected leadership properties and who were perfect in certain academic areas beginning with the 80s (Renzulli, 2002). It is invaluable to label a person as gifted in a community. Yet, a gifted person can be described as a hunter in one culture while he is described as a student in another. The first culture may not have any of the institutions of formal education. The second culture may not have provided the opportunities for the development of hunting skills in students. ıt is important in this respect to provide all the necessary conditions in schools to make individuals capable (Sternberg et al., 2011).

Being Gifted in Science

The characteristics that distinguish gifted individuals from other individuals can be listed as advanced mental ability, special ability in various fields, sensitivity and creativity (Bildiren and Uzun, 1997; Kahyaoğlu and Pesen, 2013), and intense motivation (Bildiren and Uzun, 1997; Griggs, 1984; Kahyaoğlu and Pesen, 2013) in general (Bildiren and Uzun, 1997; Kahyaoğlu and Pesen, 2013). Gifted individuals can be educated according to their interests and abilities, taking into account the characteristics of the experts in that discipline. Thus, it can be possible to raise an individual as an artist who creates unique works just as it can be possible to raise a literary man who can create a text awarded by Nobel prize or to raise a scientist who can discover vaccine for an epidemic. At this point, an examination of the characteristics of individuals gifted in science demonstrates that those individuals are interested in collecting and organising data- which is similar to the properties of disciplined mind, that they are curious about objects and their environment, have interest in researching scientific facts, have tendency to make observations and to ask questions (Stott and Hobden, 2016; Taber, 2007), that they create mathematical models, make creative and valid explanations, are ready for abstract thinking, are ready to live with uncertainties and are eager to set up hypotheses, to use variables in a fair way and to make guesses (Taber, 2007). At the same time, it is stated that these individuals want to learn in depth, continue to work diligently to improve their own choices (Griggs, 1984; Rayneri, Gerber & Wiley, 2003; Taber, 2007) and produce high-quality work (Taber, 2007). In order to raise gifted individuals with these characteristics, science curriculum primarily focus on that students should learn disciplines by

doing just like scientists do and they should understand and employ science in the real world and learn ideas in depth (Rakow, 1988; VanTassel-Baska, 1998). Such curricula should also guide students to learn the concepts of science by using upper order thinking skills such as critical thinking, creative thinking and problem solving. It is also important that such curricula aim to teach students knowledge specific to science in the process of problem-based research (Gallagher, Harradine and Coleman, 1997; Rakow, 1988; VanTassel-Baska, 1998). Use of technology as an instrument in learning should also be included in enriched environments which are prepared for gifted students (Pramathevan and Fraser, 2019; Rakow, 1988; VanTassel-Baska, 1998). Those students should be given the opportunity to design their own experiments and they should be supported to learn scientific process skills through applications of experimental design (Rakow, 1988; VanTassel-Baska, 1998).

Research has demonstrated that enriched curricula of science are influential in students' scientific process skills and that they promote their achievement (Özdemir, 2017). It is also stated that the research process as learning experience contributes to epistemological belief and to motivating factors- which constitute the elements of self-regulated strategy use in science education (Neber & Schommer-Aikins, 2002). Besides, the self-efficacy that gifted students develop on the basis of their experiences by means of learning experiences offered them and their research activities influence their scientific research skills (Yoon, 2009). Teachers are also aware of the fact that learning will be more effective if students do what they enjoy in enriched learning environments. It is because learning experiences are organised according to the things that students enjoy in such environments. For instance, learning will be more meaningful when the focus is on a problem within life which students will enjoy solving (Hébert, 2002). The enriched learning environments that are offered to students are even more important for students who come from lower socio-economic environments (Fetterman, 1988; Hébert, 2002) because such students do not have the possibilities such as access to computers- which rich families provide their children to support applications at school- or possibilities to improve their abilities such as participation in art activities and sports competitions (Hébert, 2002). Research has shown that gifted children in Turkey encounter various problems in science education. One of the studies found that the problems centred on concept teaching especially, laboratory activities, lessons or exam questions, course materials and gaining research skills (Çelikdelen, 2010). Gökdere, Küçük and Çepni (2003) also stated in their research that the teachers of gifted students have problems and need help with current learning approaches, assessment and evaluation, planning and implementation of research projects, questioning techniques and use of laboratory approaches. Similarly, the study of Gökdere and Çepni (2004) shows that teachers need in-service training about project based learning activities, modern learning theories and laboratory approaches. In addition, Gökdere, Küçük and Çepni (2004) concluded that science teachers connected between educational technology and a little technological material and also they do not use educational technologies. In this context, it is important to offer both gifted and ungifted students enriched learning and teaching environments to raise them as individuals who have knowledge adequate to specialise in a discipline, who learn in-depth, who can set up interdisciplinary associations, who can suggest original ideas in solving real-world problems and who enjoy the process of researching information about relevant discipline. Efforts are made to offer gifted students such environments in centres for science and art education- which are under the Ministry of National Education. The necessary conditions should be provided for students in such institutions so that they can grow up as individuals who have properties of disciplined teaching. Revealing the ways in which students who are found to be gifted in science according to their interests and capabilities after going through the first stage offered by Gardner (2008) can shed light on regulations in relation to enriched environments to be offered to those students. Therefore, this current study aims to determine gifted students' ways of disciplined thinking and following sub-questions are searched:

- How do gifted students in science make real life connections?
- How do gifted students in science learn science in depth?
- How do gifted students in science make interdisciplinary connections?
- How do gifted students in science think specific to science?
- How do gifted students in science get motivated to live in a disciplined way?

Method

This study- which aims to determine gifted secondary school students' ways of disciplined thinking- uses the descriptive method. The research data were collected through interviews- a method of data collection. Thus, the gifted secondary school students were interviewed. Interview method was chosen because the results obtained from the scale about disciplined mind or synthesizing mind one of the five minds, do not reveal in-depth data and they are affected by their self-evaluation (Altındağ, 2015; Can Aran and Senemoğlu, 2021), students' interest or attitude towards science and social pressure applied by parents and teachers more (Singh, Granville ve Dika, 2002). This research was carried out with middle school students because Gardner (2008) states that disciplined mind features are developed in puberty. Also we started to plan this research based on the hypotheses that gifted students will present rich-data about the indicators of

disciplined thinking when we considered on the results of the previous research about high achievers on the five minds (e.g. Altındağ, 2015; Can Aran, 2014).

The Study Group

The study group was composed of 10 secondary school students gifted in science. Criterion sampling method was used in the study. The criterion set in selecting the participants was to be gifted in science. The criterion was set according to the scores the students received in centres for science and art education. Participants who got 130 point and more from revised version of Wechsler Intelligence Scale for Children (WISC) and Anatolian Sak Intelligience Test (ASIS) were joined to this study. WISC developed by David Wechsler in 1949, was prepared for children aged 6-16. This scale was revised and standardized in 1974, thus WISC-R (Revised Version) was born (Bildiren, 2017). In addition, Anatolian-Sak Intelligence Scale (ASIS), which is Turkey's first local intelligence scale, is developed by Professor Ugur Sak and his team and applied to children between 4 and 12 years old. It based on Cattell-Horn-Carroll theory of cognitive abilities (CHC). It objectively measures general intelligence and the main components that make up general intelligence. Consisting of seven subtests, ASIS provides eight different performance profiles (General Intelligence Index, Verbal Potential Index, Visual Potential Index,Memory Capacity Index,Verbal IQ, Visual IQ, Scan Index). Application of it takes 25-45 min and scoring time takes 3 min. The pilot phase of ASIS scale was completed with 1201 children aged 4-12, the standardization phase was completed with 4641 children and the validity and reliability studies were completed with over 800 children, including special education groups. ASIS is the most representative intelligence test in terms of sample size per age group among individual intelligence tests in the world (Proje IQ, 2015). Validity and reliability values were determined at very good and excellent levels. The component internal consistency and retest reliability coefficients of ASIS were excellent, the subtest internal consistency and retest reliability coefficients were good and very good, and the inter-rater reliability was excellent on the subtest basis. In particular, the median of internal consistency reliability coefficients being over 0.90 provides very reliable results for evaluations for diagnosis, selection, placement and intervention (Sak et al., 2016). The Turkish Ministry of Education used the WISC-R test in previous years and has used the ASIS intelligence tests in recent years for identifying gifted students for the Science and Arts Centers. These tests are used in the final phase of identifying gifted children. In the first phase, classroom teachers nominate students and then students take a group-administered test of ability. In the final phase, they are administered individual intelligence tests, such as WISC-R etc. (Bildiren, 2018). The descriptive data about the participants are shown in Table 1.

Table 1 The participants' features

Student codes	Gender	Grade levels	Type of the individual intelligence test applied
Ö1	F	8	WISC-R
Ö2	F	8	WISC-R
Ö3	M	7	WISC-R
Ö4	F	5	ASIS
Ö5	F	8	WISC-R
Ö6	F	7	WISC-R
Ö7	M	6	WISC-R
Ö8	F	7	WISC-R
Ö9	F	7	WISC-R
Ö10	F	7	WISC-R

As clear from Table 1, each student was given a code from 1 to 10; and thus, the student coded as 1 was referred to as Ö1. ıt is also evident from the Table that there are 8 female and 2 male students in the study group. As to the grade levels, 3 students are the eighth graders, 5 students are the seventh graders, 1 student is the sixth grader and 1 student is the fifth grader. It is clear that the sample includes students of all grade levels.

The Data Collection Process and Data Analysis

The participants were interviewed so as to reveal gifted students' ways of disciplined thinking. The interview form developed by Can Aran (2014) was used in the interviews. The form contained five questions about setting up connections with real-world, learning in-depth, setting up interdisciplinary connections, thinking like a scientist and getting motivated to live in a disciplined way- which were the indicators of disciplined mind. The first three questions on the form expected students to exemplify the ways of using knowledge in real-world, to explain the ways they used in learning in depth and to give examples for how they make connections between disciplines. Question four assigned students a topic of research and asked them the way they would follow in doing the research. In this question to see whether students to know the steps of scientific process and usage of them in a real life case or not, it is asked to students "your teacher wants you to search whether a plant that does not receive light can grow or not. Which steps do you follow to search this subject?". Question five aimed to find whether or not students enjoyed learning the discipline. An effort was made with it to reveal the extent to which students were motivated to live in a disciplined way in science. The research was conducted using a voice recorder in line with the questions in the interview form. The records obtained were deciphered by the researchers in writing.

Descriptive analysis method was used in analysing the data. Data is summarised and interpreted according to predetermined themes in descriptive analysis (Yıldırım and Şimşek, 2011). Accordingly, the research data was analysed on the basis of the themes of setting up connections with real-world, learning in depth, setting up interdisciplinary connections, thinking like a scientist and getting motivated to live in a disciplined way- which were the indicators of disciplined mind. The qualitative data were coded on MAXQDA 2020 programme. Following all the analyses, the data were visualised as themes, codes and sub-codes with MAXmap.

Validity and Reliability

In qualitative research, the concept of validity comes before the concept of reliability (Yıldırım & Şimşek, 2011). Validity includes the matching of statements that are created, clarified or tested with ordinary situations in human life. There are two questions that include whether real situations and scientific explanations match. The first is whether the scientist actually observes or measures what he/she intends to observe and measure. This question is about internal validity. The second question is to what size groups the abstract structures and assumptions created, developed and tested by the scientific researcher are applicable. This situation is related to transferability, which is related to external validity (LeComplete and Preissle Goetz, 1982). In order to ensure the internal validity of the data obtained from the research, an interview form developed by Can Aran (2014), for which expert opinion was taken before, and the pilot and final application of which were conducted on secondary school students was used. The comprehensibility of the questions in the interview form was tested by conducting a pre-interview with a gifted middle school student who would not participate in the final application. Internal validity for qualitative data in the study was also provided by using purposeful sampling (Lincoln & Guba, 1985). Students were selected according to the criteria of being gifted in science. In this context, the study group of the research was selected using the criterion sample. For external validity in the study, themes for other researchers who will study the same subject and the codes under these themes were clearly presented in the findings section. At the same time, students were asked to explain their thoughts in detail and give examples during the interview. At this point, the research results were presented with detailed descriptions by including the quotations of the students. In addition, the scope and limitations of the research were defined in order to make logical generalizations possible. In order to ensure reliability in Qualitative Research (LeComplete and Preissle Goetz, 1982), questions were asked to all students in the interview using similar approaches. In addition, a voice recorder was used. Also, the conceptual framework and assumptions of the research have been described in detail. The data were also read by two separate researchers and the codes were compared. Then inter-rater reliability was calculated. The comparison demonstrated that there was over 71% agreement.

Findings

The research findings were put into themes labelled as setting up connections with real-world, learning science in depth, setting up interdisciplinary connections, thinking like a scientist and getting motivated to live in a disciplined way. Each theme was modelled on the basis of codes and subcodes. In addition to that, students' remarkable examples were also included in each theme.

Making Real-World Connection

How students make connections between science and real-world was investigated through interviews with gifted students. As a result, the students' views in relation to making connections between science and real-world shown in Fig. 1 were obtained. Figure 1 includes frequency tables showing the codes and number of students in relation to setting up connections between science and real-world.

According to Fig. 1, most of the students (f = 8) set up ties between science and life at home. The students who make connections between science and life at home described the connections in the sub-codes such as electrical appliance, need-oriented design, in the kitchen, regulating sleeping hours and moving furniture. Student Ö4, who said that he/she used science in life at home, made the following statement:

> "The physics teacher at the centre for science and art showed it to me. The thing that is heavier on the scales goes down. I made hangers for hair grip based on this principle. When I hung too many on one of them, it fell down."

In relation to having a pet, Ö3 made the statement:

> "We have an aquarium and fish in it. I immediately remember the subjects we have learnt about animals. What animals and what plants can be kept in an aquarium? I mean I help my father. There may be things that my father doesn't know about. I can help him in this respect."

Student Ö8, who said that he/she used the knowledge he/she had learnt in science in the kitchen, said, "*we learnt something about yoghurt fermentation. It was about bacterial*

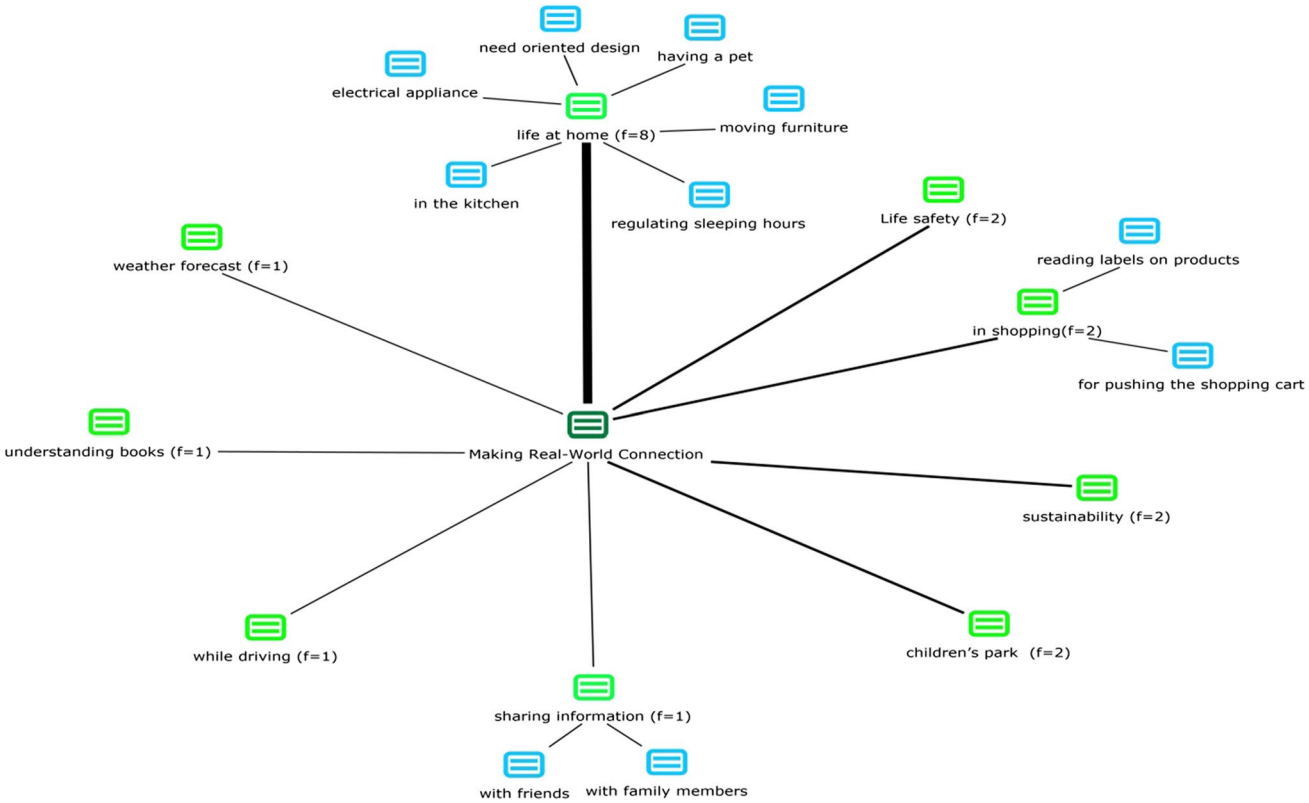

Fig. 1 Codes representing students' views of connections between real-world and science

growth. I experimented with it". Ö5, on the other hand, said, *"it is beneficial to me in terms of sleeping hours. I mean the time when the sun sets"* in relation to regulating their sleeping time according to knowledge learnt in science.

The areas where students associated what they had learnt in science with real-world most frequently apart from life at home were protecting life safety (f = 2), recognising the structure of toys in children's parks (f = 2), having sustainability for the environment (f = 2) and shopping (f = 2). In relation to life safety, Ö7 made the statement *"one gets electric shock if there is no electrical insulation- as you know. One should not touch electrical systems without gloves or with bare hands."* Ö1 stated the ties he/she had set up between what they had learnt in science and children's park as *"for example gravity on a swing, and its speeding up and slowing down with the effects of gravity."* The remarkable statement made by Ö9 in relation to using the knowledge learnt in science to protect the sustainability of the environment was as in the following: *"I learnt they deodorants were harmful to nature. So, I use roll on perfume now."* Ö5 explained how he/she used the knowledge learnt in the science course in shopping as:

> "It becomes difficult to push the shopping cart when there is a problem on its wheels or when we put 2 or 3 packages of chocolate on it. You can push it easily if the wheels turn smoothly. If such things- I mean the force of friction- had not been discovered, you would try to push it and you wouldn't know how wheels useful wheels were."

Learning Science in-depth

Another purpose of the interviews with gifted students was to reveal the ways they followed in learning science in-depth. The participants stated that they employed several ways in learning science. The codes in relation to learning science in depth and the frequencies for the number of students are shown in Fig. 2 below.

It is clear from Fig. 2 that the majority of the students (f = 7) reach in-depth knowledge on the internet. Some of the students said that they reached knowledge on the internet through such sites as Wikipedia, e-homework and Do You Know These. Ö4 said that he/she learnt about science on the internet as in the statement "*I usually search on the internet on differing sites*." Ö6 said, "*I study the subject on various sites with videos of teaching.*" By mentioning the name of the web site, Ö8 said, "*there is a web site called Do You Know These. I follow it*." Ö1, on the other hand, made the statement "*for example, e-homework is available. Users*

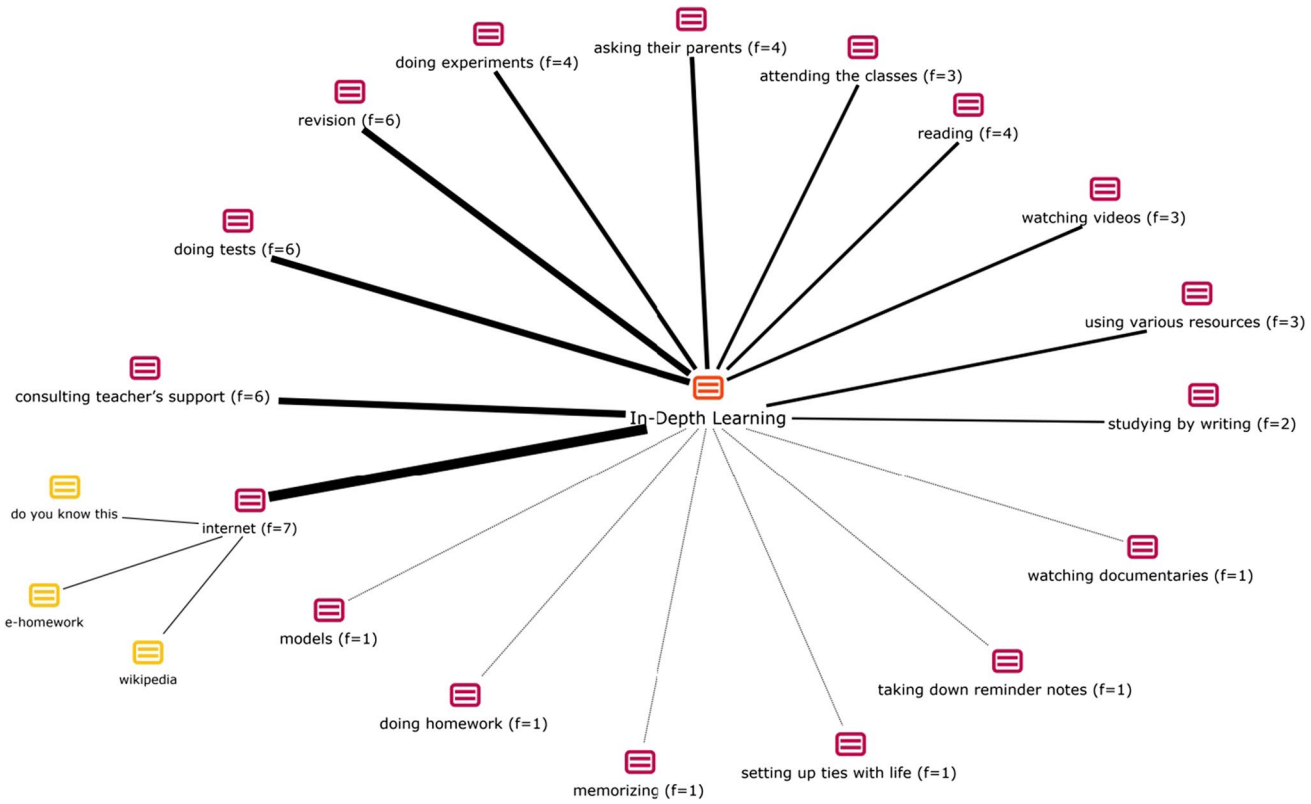

Fig. 2 Codes for gifted students' in-depth learning in science course

ask questions and others answer the questions on the web site." The participants said that they reached in-depth knowledge in physical science classes by making revision, doing tests and consulting their teacher's support mostly apart from using the internet. In this respect, student Ö5 said, "*I make regular revisions everyday*" while Ö4 said, "*I tell my mother about the subjects that I study to see whether I know the subjects adequately*." Ö9 said, in relation to revising, "*I revise the experiments by using the notes in the evenings*." Another participant, Ö1 said that he/she answered questions to understand the subjects better as in the statement "*I remember better when I make a mistake in answering a question. I keep it in my mind better*." Ö4, on the other hand, stated that he/she consulted the teacher's support by saying "*I ask the teacher again the things that I do not understand*." Student Ö9 expressed his demand for additional classes from the teacher in the statement "*I ask the teachers for extra classes at school*." Another gifted student, Ö2 said that he/she used models which were the instruments for learning as "*for example we made DNA models in some subjects. I understand better with concrete examples and models"*. The gifted students included in the research also stated that they used experimenting- a significant way of learning- to learn in science. In this respect, Ö4 said, "*I benefit from the physics teacher in the Centre for science and art. We revise the science subjects that I didn't understand at school with experiments."* Ö10 said in relation to the code of experimenting, "*I cannot go beyond memorisation at home. But I learn better in the laboratory in the art centre when I have time."* Ö 1, in relation to learning by doing experiments, said the following: "*I mostly study by practising. I mean I try to practise by doing things at home the things that we learn at school. I try to do experiments. For example, doing experiments with an egg."*

Making Interdisciplinary Connections

The gifted students' thoughts on the disciplines with which they make connections the most frequently while learning science were also obtained in this study. Accordingly, they stated that hey benefited from such courses as mathematics, Turkish, Social Sciences, Biology, Physics and English in learning science. The codes and frequencies representing the students' views are shown in Fig. 3.

It is apparent from Fig. 3 that the discipline with which students make connections the most frequently is mathematics. Ö4 made the statement "*in my opinion it is mathematics only. I always encounter operations and numbers in science course because it is a numerical course. So, mathematics is closer to it.*" Ö6 said, "*Things like genetic codes are related*

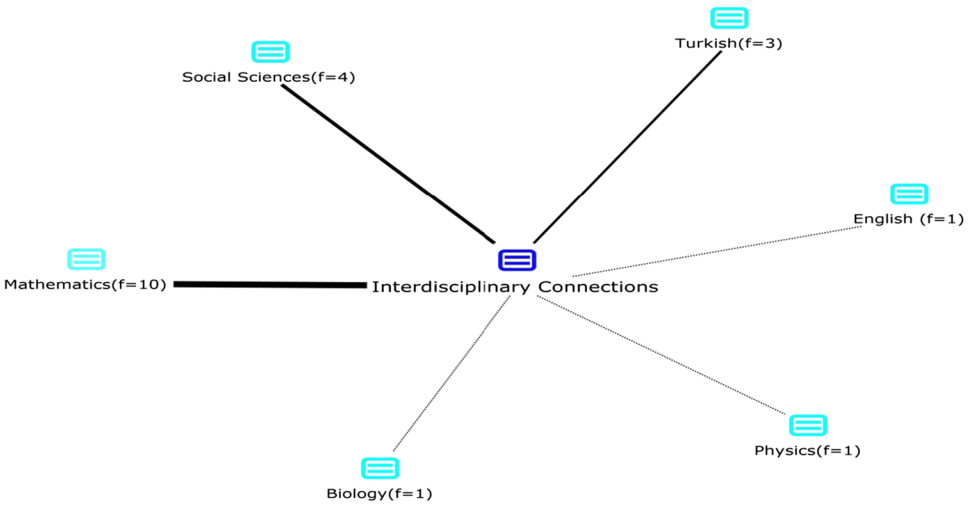

Fig. 3 Codes for interdisciplinary associations gifted students set up in classes of science

to mathematics. Calculating the probabilities is mathematics" and emphasised the ties between the course and science. In addition to mathematics, most of the students make connections between such subjects of geography as seasons and science. In relation to social sciences, Ö6 made the statement "*sometimes, there are subjects that science and social sciences have in common. Such as the climate. It is useful because I sometimes say to myself, 'We have learnt it previously'. We learn about scientists in social sciences."* Ö7 thought that what they had learnt in social studies course made it easier for them to learn science and said, "*We learnt about natural disasters in social studies course. It seemed easier when we encountered it in science course."* It was remarkable that Ö8 associated the English course with science course in the statement "*because terms in a foreign language are becoming more and more difficult as they grow in number. It is necessary to learn Latin."*

Thinking like a Scientist

This paper also aimed to reveal the ways gifted students follow in thinking like a scientist in classes of science. As a result, the participants mentioned several ways of thinking like a scientist. The codes and frequencies representing the gifted students' views are shown in Fig. 4.

Accordingly, the participants' views heavily centre on the themes of doing experiments and keeping variables under control. Student Ö9 said, "*I would experiment with it, I would do experiments to research whether it is real or not"* in relation to the code of doing experiments whereas Ö4 said, "*I would first experiment with it at home"*. As to the code of keeping variables under control, Ö2 made the statement "*I would put the plant in a covered box. I would give water and other things to it, not only light. I would look after the plant in this way."* Ö6, on the other hand, said, "*I would set the variables which I would keep constant (researcher:*

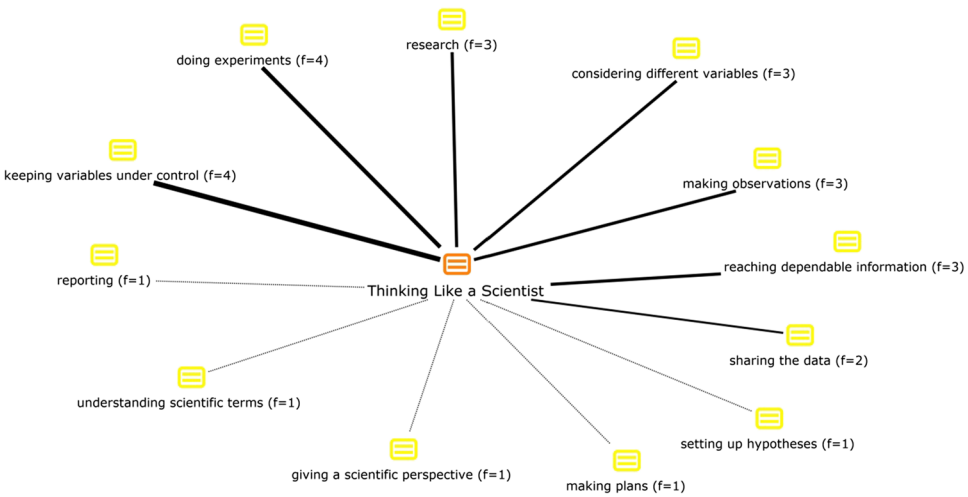

Fig. 4 Codes for gifted students' thinking like a scientist

what are they? Can you give examples?) if it is light, the heat will be the same, I would give the same amount of water. Both would be the same plant in the same place." The codes which were mentioned the least frequently (f = 1) were setting up hypotheses, making plans, giving a scientific perspective, understanding scientific terms and reporting.

Getting Motivated to Live in A Disciplined Way

Students' interest and capabilities in the area were regarded as the criterion for students gifted in science. In this respect they are expected to be motivated to live in a disciplined way. The codes and frequencies reflective of the students' motivation to live in a disciplined way are shown in Fig. 5.

It is clear from Fig. 5 that the gifted students included in the research mostly stated views on liking the process of learning (f = 10). Second most frequently stated views were on the codes of having interest in the subjects of science and of considering it necessary for their future life (f = 7). In relation to liking researching the subjects they do not know of- a sub-code of the code of liking the process of learning- Ö3 stated his/her views as in the following:

> "For example, whales are huge. I had seen them once. How do they live? What do they eat? I thought they ate fish, but I learnt that they ate planktons. I thought they opened their mouth and ate lots of fish at a time. I learnt that they opened their mouth, something like a filter formed while water passed through their fin and fish sent it to its stomach immediately and ate planktons at that moment."

Ö1, just like Ö3, said that he/she liked researching the subject of living creatures under the sea in the statement "*I think it is related to science. I like the creatures living under the sea. I like researching them"* Ö9, in relation to the same subcode, made the statement *"I have books about the subjects I wonder. I research them and write about them. For example, why are elephants so heavy?"* The following is the statement made by Ö5 about liking unexpected cases: *"I love those experiments in chemistry. The ones with explosions. They are enjoyable and unexpected."*

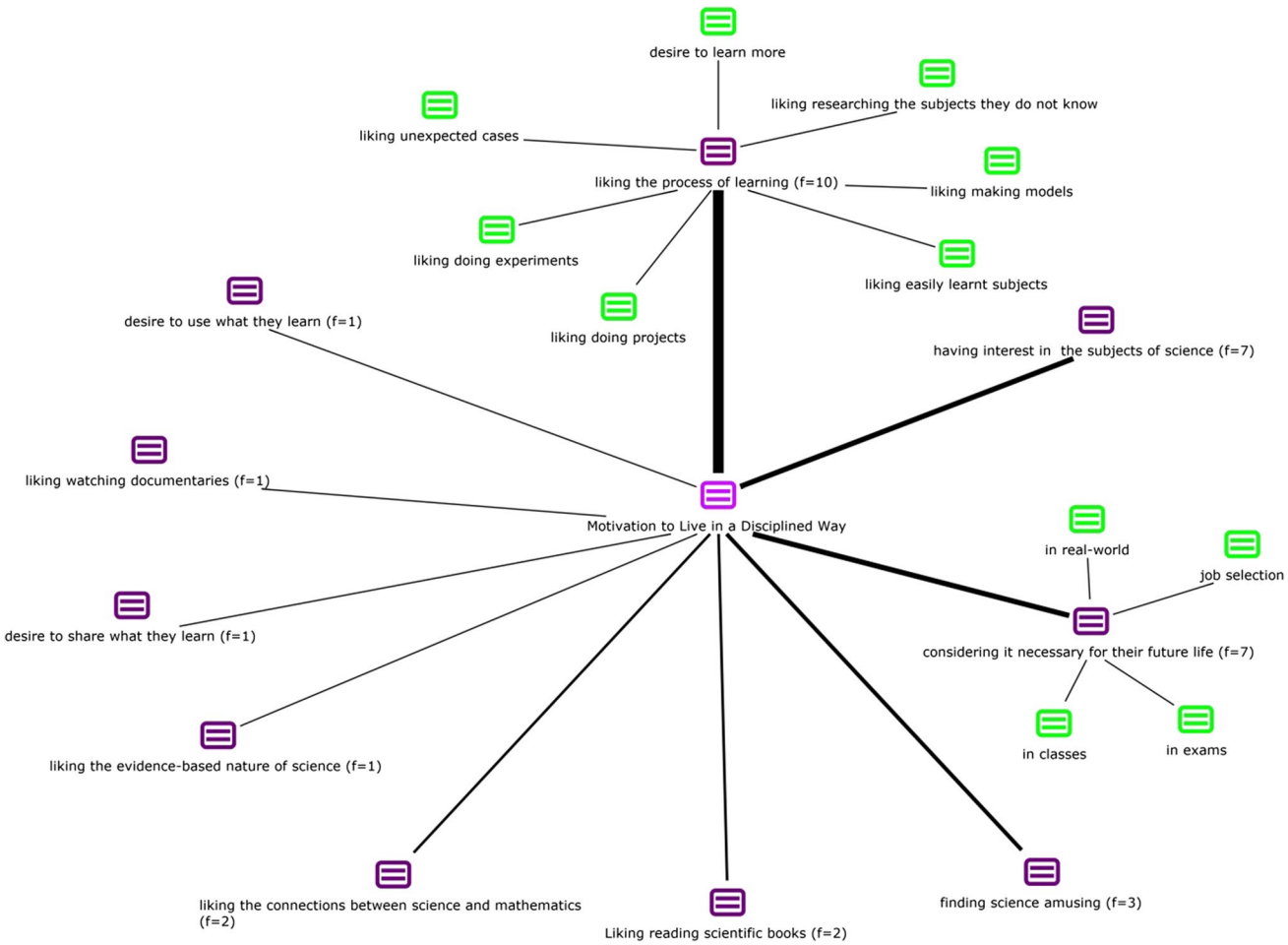

Fig. 5 Codes for gifted students' motivation to live in a disciplined way

Ö8- in relation to the sub-code of liking doing experiments- said, *"Making machines, connecting them to electricity, making robots. We had code language. Things like writing codes. We wrote codes and the robot obeyed the commands."* Ö5 explained his/her desire to do more complicated experiments in the statement *"I want to do more complicated experiments. The ones containing droppers with legs."* In relation to the code of desire to learn more, Ö9 said, *"I wanted to learn about the solar system and about how large the universe was"* Ö3 made the statement:

> "For example, animals have differing body structures. I want to learn about them very much. How do they live? What can we do? Can we do things like them in the future? Some people see some things in their body for instance. Problems occur in the world and they can solve the problems. For example, there is something in an animals' body, and the people look at the animal's body. How can it do such a thing to the animal?"

For the sub-code of liking doing models, Ö2 made the statement *"there are DNA models at home. We made them. I liked placing the nucleotides."* In relation to the sub-code of liking doing projects, Ö5 said, *"I can spend one and a half hours and even two hours on a project if it is a project that I like."* As to the code of liking easily learnt subjects, some students gave examples from the subjects of biology whereas some others mentioned the area of astronomy. Ö4 stated his/her view on the researcher's questions as in the following:

> *Researcher*: what makes you happy and what makes you unhappy about the science course?
> *Ö9:* The sun, the world and the moon make me happy. What makes me unhappy is living creatures.
> *Researcher:* Why do living creatures make you unhappy?
> *Ö9:* It is difficult for me to learn about the birth of lots of living things and about what they live on and whether they have hair on their skin.

Ö10, who found the subjects of biology difficult, stated his/her feelings as in the statement *"when it is a subject that I like, it makes me happy. Those which make me unhappy are the subjects such as the subjects of biology; they are difficult for me to learn."* The participants also stated their views on their desire to use what they learn, on liking watching documentaries, on desire to share what they learn and on the evidence-based nature of the science course.

Discussion

The gifted students' views were found to focus on the theme of setting up associations between science and real-world and on the code of life at home (f = 8). The students said that they used what they learn in science in explaining the situations related to electrical appliance, design according to need, having a pet, in the kitchen, regulating their sleeping hours and moving furniture. Considering the fact that a characteristic of gifted students is their curiosity about their environment (Taber, 2007), it can be said that it is expected of them to use their knowledge about science in explaining the phenomena they encounter at home. Consistently, Harty and Beall (1984) reached the results that gifted girls have more positive attitude about "usefulness of science when playing at home". When the quotations of the gifted students about the code of life at home are also examined, it is noteworthy that the students thoroughly examine the events around them. When the results of Can Aran's (2014) interview with non-gifted students to reveal the disciplined thinking ways of secondary school students in the field of science are examined, it is noted that these students make more superficial explanations unlike gifted students and their examples are limited to the daily life examples that they learned in the course. In addition, one of the remarkable findings of the study is that one of the gifted students stated that they were inspired by the knowledge they learned at the Science and Art Center and made a tool that makes their daily life easier. At this point, the enriched environment offered to students is of great importance. This finding is in parallel with the finding that Özdemir (2017) reached in his research that the enriched teaching program in the field of science has an effect on students' scientific process skills and increases student success. At the same time, as Hébert (2002) stated, learning will be more meaningful when it focuses on a problem within life that the student will enjoy solving in the learning environments offered to students.

The participants said that they mostly used the internet in learning science in depth (f = 7). It was found that the students resorted the most often to teachers' support, answering test questions and revising in in-depth learning. In addition to the availability of studies in the literature demonstrating that gifted students have higher academic achievement than ungifted students (Altun and Yazıcı, 2012), Can Aran (2014) suggests, in a study conducted with the inclusion of ungifted secondary school students, that the majority of the students with high achievement use the internet, answered test questions and made revision in learning in depth. At this point, it is important to include technological tools in the learning environments to be presented to students or to present the enriched environment that will enable them to learn in a technology-supported way (VanTassel-Baska, 1998). In this study, unlike Can Aran's (2014) study with non-gifted students, it was observed that some of the gifted students stated that they learned deeply by doing experiments, too. Consistently, Harty and Beall (1984) reached the results that gifted boys have more

positive attitude about "spending more time doing science experiments". At this point, as stated by VanTassel-Baska (1998) and Rakow (1988) gifted students should be given the opportunity to organize their own experiments and they should be supported to learn scientific process skills through experimental design applications.

The majority of the gifted students included in the research stated that they make connections between science and mathematics in learning science (f = 10). Lynch (1992) also reached the conclusion that achievement in mathematics predicted achievement in biology rather than achievement in languages- which can be thought to be supportive of the findings obtained in this study. One of the important findings of the study is that a gifted student participating in the study stated that they established a connection between the science course and the English course. On the other hand, less than half of the students participating in the study expressed an opinion regarding establishing connections between other disciplines and science. The reason for it might be that less association was set up with other disciplines in the curricula used with gifted students. Gardner (2008) argues that it is impossible to be skilled in any subjects with the perspective of only one discipline. Therefore, it is believed that the more disciplines are associated, the more skilled the students will become. At this point, it is thought that with enriched environment applications that will be presented to gifted and other students to develop disciplined minds, they can be provided with meaningful learning by establishing connections between science and different disciplines. The fact that all of the students with medium and high achievement level, and only one of the students with low achievement level, who participated in the research of Can Aran (2014), expressed an opinion about establishing interdisciplinary connections confirms the opinion about students' meaningful learning. Stott and Hobden (2016) reached the conclusion in their study that successful gifted students establish links between different knowledge. At the same time, considering that gifted students fail in areas other than their areas of interest (Sumida, 2013), it is thought that practices aimed at developing disciplined mind will increase the success of gifted students.

The majority of the gifted students stated views mostly in the codes of doing experiments in science (f = 4) and controlling a variable (f = 4) in relation to the theme of thinking like a scientist. It was observed on examining the participants' views on the theme that they described scientific thinking with the stages of scientific process. The interpretation of the finding could be that secondary school students were knowledgeable about the stages of scientific thinking and that they followed the stages in learning science. In a similar way, Lee and Ha (2012)' study results also showed that the viewpoint of science-gifted students were similar to absolutism and empiricism. Liu and Lederman (2010) also found that gifted students were aware that science was evidence-based and experiment-based. In support of it, this study found that the participants stressed the importance of reaching dependable knowledge in science course and that they said science gave them a scientific perspective. In the research of Can Aran (2014), most of the successful students who are not gifted and very few of the unsuccessful students expressed opinions on the scientific process steps. This situation reveals the importance of enriched environment practices for completing the learning deficiencies of gifted and non-gifted students to ensure scientific thinking.

This current study also found that the participants stated the greatest number of views on liking the process of learning in the theme of getting motivated to live in a disciplined way (f = 10). Similarly, Kahyaoğlu and Pesen (2013) found in their research that gifted students have high motivation to take an active role in using different strategies to build new knowledge. Can Aran (2014), in a study investigating the properties of ungifted secondary school students' disciplined mind, found in a similar way that the majority of the students with high achievement stated views in relation to liking learning new knowledge. Yet, it is important to take into consideration the studies which have demonstrated that gifted students' levels of motivation in science (Kahyaoğlu, 2013) and academic self-concept levels (Altun and Yazıcı, 2012) are higher than ungifted students' to interpret this finding. It was remarkable on examining the code of liking the process of learning in detail that the gifted students stated views on the sub-codes of liking researching the subjects they did not know. This is consistent with the findings of Özarslan and Çetin (2018)'s research. In addition, participants of this research stated that they were liking encountering unexpected events while doing experiments. It was a finding consistent with the one that students enjoyed encountering interesting activities and activities that they had not seen before and actively taking part in those activities, associating what they had learnt with real-world and making their learning more permanent by configuring it-which was obtained by Özdemir (2017). At the same time, the result of the research that gifted students like more tactile and kinesthetic learning activities such as experimenting and doing research while being motivated to live with discipline is in line with the findings of Rayneri, Gerber and Wiley (2006) and Turki (2014). The gifted students in this current study stated second greatest number of views after this code on having interest in the subjects of science and considering the area of science necessary for their future life (f = 7). It was a finding in parallel to the ones that gifted students had high attitudes towards science course obtained by Kahyaoğlu & Pesen (2013) and that gifted students had high interest in the subjects of science obtained by Kalaycı and Coşkun (2020).

Implications

This study aimed to determine the indicators of gifted secondary school students' disciplined mind. Researchers can analyse in the future studies the properties of gifted students' disciplined thinking they display in various disciplines. The points gifted students have in common in science course at different stages of schooling as well as the points different can be revealed. In this way, precautions can be taken in advance so as to develop disciplined mind in science from lower grade levels to upper grade levels. In addition to that, future studies can also investigate whether or not disciplined mind properties of students who are not gifted but who have high achievement levels differ from those of gifted students.

Limitations

The results of exams given by centres for science and art education are used in describing gifted students in Turkey. Therefore, the students gifted in science are thought to have similar properties in Turkey. Yet, the data collected in this study are restricted to the ones obtained through interviews. Supporting the research with data coming from surveys and observations is believed to be important in terms of the persuasiveness of data.

Conclusion

The science course aims to raise students like scientists. Scientists are the individuals who work persistently in order to find solutions to real-world problems. In this context, it is important to raise students who have properties of disciplined mind in science in terms of preparing them to be scientists. Demonstrating the different ways that students who are thought to be gifted in science especially follow in learning science will guide the educators who work with the intention of making all students like the science course and of raising individuals who think in a disciplined way. It was found in this study that the views stated by the participants centred around the theme of associating science with real-world and in the code of life at home. The students said that they used the internet the most often in learning science in depth. The majority of the gifted students stated the greatest number of views on doing experiments in science and on controlling a variable in the theme of thinking like a scientist. As to the theme of getting motivated to live in a disciplined way, the students stated the greatest number of views in relation to liking the process of learning.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in this study involving human participants were in accordance with the ethical standards and approved by the board of Developing Gifted Students of The Ministry of National Education.

Informed consent Informed consent was obtained from all individual participants and their parents included in the study.

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