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Assessing the impact of differentiated instruction on mathematics achievement and attitudes of secondary school learners

Ayten Pinar Bal
Mathematics and Science Education Department, Faculty of Education, Cukurova University, Adana, Turkey
apinarbal@gmail.com

The aim of the study reported on here was to assess the impact of differentiated instruction in terms of mathematics achievement and the attitudes of secondary school learners to reveal their views on differentiated instruction. The study was designed according to a mixed method design in which both quantitative and qualitative methods were used. The study group, which constituted the quantitative dimension of the study, consisted of 2 control groups and 1 experimental group. The Mathematics Achievement Test, Mathematics Attitude Scale and a semi-structured interview form were used as data collection tools. One-way anova and descriptive analysis techniques were applied for the analysis of the data. We concluded that differentiated instruction in mathematics courses increases secondary school learners' mathematics achievement, but has no effect on their attitudes towards mathematics.

Keywords: differentiated instruction; mathematics achievements; mathematics attitude; secondary school mathematics education; teaching fractions

Introduction

Like all developing countries, Turkey attaches great importance to education and training. In recent years in particular, educational infrastructure is being reinterpreted in terms of scientific and technological developments and various seminars and in-service training courses have been developed to continuously update teaching programmes (Millî Eğitim Bakanlığı [MEB], 2018). In this context, updated mathematics curricula emphasise that teachers design their own differentiated instruction by considering learners' individual differences such as different levels of readiness, different learning abilities and different achievement levels (Dack, 2018; Tomlinson, 2014). However, even though Turkish learners' mathematics achievements have increased in recent years, the average score of Turkish learners in international exams such as the Programme for International Student Assessment (PISA), was lower (459) than the average score of learners from Organisation for Economic Co-operation and Development (OECD) countries (489) (Avvisati, Echazarra, Givord & Schwabe, 2019). In the context of mathematics lessons, it is especially clear that theoretically differentiated instruction is not at the desired level in classroom practices (Afurobi, Izuagba, Ifegbo & Opara, 2017; Melesse, 2015; Senturk & Sari, 2018). Differentiated instruction is the process of determining the content according to the learners' abilities and their levels of success, taking learners' level of readiness and their individual performance in mathematics into account.

From the literature it is evident that studies assessing differentiated instruction in mathematics courses generally focus on primary school (Bulley-Simpson, 2018; Prast, Van de Weijer-Bergsma, Kroesbergen & Van Luit, 2018), secondary school (Awofala & Lawani, 2020; Millikan, 2012), undergraduate and graduate levels (Afurobi et al., 2017; Chamberlin & Powers, 2010; Dack, 2018; De Jager, 2019; Melesse, 2015). However, a limited number of studies have been conducted on secondary school level (Ogunkunle & Henrietta, 2014). As a result of the differentiated instruction applied to instruction of learners from lower socio-economic levels, Bulley-Simpson (2018) conclude that learners' meaningful learning and achievement were increased. On the other hand, in a study where learners' achievements and teachers' opinions in classes for which differentiated instruction was applied in a secondary school algebra course, Millikan (2012) found that learners' achievement and meaningful learning had improved as a result. In a quasi-experimental study, Chamberlin and Powers (2010) found that undergraduate students' experiences in mathematical understanding increased under differentiated instruction.

Considering these reports, my study was conducted to assess the impact of differentiated instruction in terms of secondary school learners' academic achievement and attitudes in the context of the sub-learning field of operations with fractions in mathematics, and also to investigate the learners' views on differentiated instruction. Operation with fractions is taught in fourth, fifth and sixth grades mathematics in Turkey (MEB, 2018). However, since the subject of fractions is dependent on the relationship between the part and the whole, it is one of the subjects that is difficult to learn and learners often struggle with this concept (Barbieri, Rodrigues, Dyson & Jordan, 2020; Durkin & Rittle-Johnson, 2015; Malone, Fuchs, Sterba, Fuchs & Foreman-Murray, 2019; Schumacher & Malone, 2017). For this purpose, the following sub-objectives were set:

1) To determine if there is a significant difference in pre-test and post-test mathematics achievement test scores between learners in the experimental group, for which differentiated instruction was applied, and learners in the control groups, for which the traditional teaching method was applied.

2) To determine if there is a significant difference in pre-test and post-test mathematics attitude scores between learners in the experimental group, for which differentiated instruction was applied, and learners in the control group, for which the traditional teaching method was applied.
3) To determine what learners in the experimental group thought about differentiated instruction in a Turkish context.

Literature Review

In the educational process, various teaching strategies and assessment tools have been applied in the context of renewed curricula in order to enable learners to make their own decisions, to solve problems and to develop as thinking individuals (Gregory & Chapman, 2002). According to Tomlinson (2014), learners need a learning experience that guides them to explore the content of the programme, which includes activities that lead learners to meaningful learning, to reach their own knowledge/thoughts, and also to reflect and demonstrate what they learn. In this context, differentiated instruction stands out as an important factor that meets the needs and interests of all learners (Smale-Jacobse, Meijer, Helms-Lorenz & Maulana, 2019). Differentiation is a dynamic process in which all children participate in the learning process (Florian & Spratt, 2013). Differentiated instruction is to determine the current developmental levels of learners and to arrange appropriate teaching in a way that will eliminate learning difficulties (Tomlinson & Moon, 2013). In addition, with differentiated instruction, learners' perceptions, interests, abilities and strengths come to the fore during the learning and teaching process (Prast et al., 2018; Tomlinson, 2014; Wan, 2017). In other words, differentiated instruction is to present teaching in accordance with learning differences in order for learners to learn best (Coubergs, Struyven, Vanthournout & Engels, 2017). This teaching approach can be applied at all grade levels and in many subjects such as fine arts, social studies, language skills, science and technology, and mathematics, and at many grade levels (Small, 2017; Whitley, Gooderham, Duquette, Orders & Cousins, 2019).

Theoretical Framework

Differentiated instruction, which uses theories that include the social constructivist approach is not only a learning and teaching strategy, but it can be considered a philosophical process in which learners freely express their unique thinking power while interacting with their social environment (Afurobi et al., 2017; De Jager, 2019; Tomlinson, 2014).

In this context, differentiated instruction refers to learner-centred learning and teaching processes guided by a constructivist approach (Maeng & Bell, 2015; Tomlinson, 2014, 2017; Wan, 2017). According to the constructivist learning approach, learners create permanent knowledge by building new information on the information they had previously learnt in social life (Brooks & Brooks, 1999). Within the same perspective, the theory of the zone of proximal development put forward by Vygotsky (1978), which expresses the socio-constructivist approach that indicates the importance of the social environment in learning, forms the basis of differentiated instruction. As emphasised in the theory on the zone of proximal development, the main purpose of differentiated instruction is to create an environment where learners can solve problems guided by teachers or more skilled peers (Laari, Lakka & Uusiautti, 2021; Small, 2017). It is of great importance to develop knowledge together with a guide to cement learning and skills in order to increase learners' success.

In terms of mathematics teaching, many mathematics teachers have stated that it is quite difficult to meet the needs of all learners in a way that also includes learners' diverse abilities, interests, learning styles and cultural backgrounds (Chamberlin & Powers, 2010; Small, 2017). In this context, Pierce and Adams (2004) emphasise that mathematics learners' interests, abilities and learning needs are different and that implementing differentiated instruction (rather than a one-size-fit-all approach) positively affects the classroom atmosphere and learners' mathematics achievement. Likewise, the main characteristics of differentiated instruction are emphasised by the standards of equality in teaching and school mathematics, as indicated by the National Council of Teachers of Mathematics (NCTM, 2000), which defines the achievement at the highest levels of mathematics and the diverse characteristics of learners.

In mathematics classes in which differentiated instruction is applied, many teaching strategies such as station, agenda, complex teaching, trajectory studies and the tiered instruction strategy can be used (Doubet & Hockett, 2018). In classes in which the station teaching strategy is used, learners are provided with the opportunity to learn in groups, and to act independently according to their individual differences (Tomlinson, 2014). The agenda strategy includes tasks that teachers determine according to the learners' level of readiness and that should be carried out within a certain period of time, and includes both common and different tasks. The tasks vary based on the learners' interests and learning styles. The purpose of the agenda strategy is to enable learners to complete their learning processes with appropriate activities according to their own learning speed. In this way, teachers can observe learners' development and learning levels and make recommendations (Doubet & Hockett, 2018).

Additionally, the aim of this strategy is to make use of learners' thoughts and ideas during complex learning. In complex learning, learners should produce different thoughts and express these thoughts with symbols. This strategy also allows learners of differing characteristics to form groups with one another. With the formed small groups, the goal is to elicit full class participation rather than the participation of only some learners. Project type studies are frequently used in trajectory studies (Tomlinson, 2014) to improve learners' productivity and to give them the ability to produce original works and manage the whole process on their own.

Finally, the tiered instruction strategy, which offers different learning environments that depend on learners' readiness, perceptions, abilities and learning styles, and which was also used for the implementation phase of this study, is increasingly important for mathematics classes in which differentiated instruction is applied (Kokkinos & Gakis, 2021; Pierce & Adams, 2004; Small, 2017). In particular, mathematics has a structure based on the prerequisite relationships between its subjects as it is a consecutive and agglomeration field. In order for a mathematical concept to be understood by learners, it is necessary to gain insight into other concepts in the prerequisite condition that are related to that concept (Dodeen, Abdelfattah & Alshumrani, 2014; Naidoo & Kapofu, 2020). From this point of view, by using a tiered instruction strategy, learners with low, middle and high mathematics pre-learning levels can learn the same subjects and make gains at an appropriate level of difficulty for themselves. Again, the learners' academic achievement and positive attitudes and motivation towards mathematical learning can be increased using the tiered instruction strategy (Sondergeld & Schultz, 2008).

Methods

This study was conducted to assess the impact of differentiated instruction on learners' mathematics achievement and attitudes in a secondary school mathematics course as mixed method research in which quantitative and qualitative methods were used together (Fraenkel, Wallen & Hyun, 2019). The tiered teaching method was used in the classroom application of the research. In this study, quantitative data were first collected and combined with qualitative data in order to explain the data in more depth, and a descriptive sequential pattern was used (Creswell & Plano Clark, 2017).

Sampling

The population of the study consisted of 87 randomly selected fifth grade secondary school learners (three groups) from a low socio-economic level public secondary school located in the southern part of Turkey. One of the three groups, which were similar with regard to gender (χ^2_{gender}=2,087 *SD* =2 $p > .05$) and mathematics exam scores ($\chi^2_{math\ scrore}$ = 5,796 *SD* = 6 $p > .05$), was chosen to be the experimental group while the other groups were the control groups.

The qualitative groups for the interviews were determined according to the criterion sampling method as purposeful sampling method. In criterion sampling all cases involved should meet some criterion in order to be included (Creswell & Plano Clark, 2017; Miles, Huberman & Saldaña, 2020). In this context, the opinions of the school counsellor and the classroom teacher were taken and 15 learners who had not received differentiated instruction before and had high, medium and low mathematics achievements were included in the study by adhering to the voluntary principle. Face-to-face interviews with the learners were recorded by taking notes and making audio recordings.

Data Collection Tools

The Mathematics Achievement Test, Mathematics Attitude Scale and a semi-structured interview form were used as data collection tools. The measuring tools in question are discussed in detail below.

Mathematics achievement test

A multiple-choice achievement test with 20 questions, which was developed by the researcher and prepared in accordance with the fifth-grade concept of fractions, was applied. In order to determine the suitability of the questions regarding the validity of the content, two experts in mathematics teaching and two mathematics teachers were consulted. In the next stage, the draft achievement test of 20 questions was applied to 131 Grade 5 learners who learned at the previous grade level (Balta & Eryılmaz, 2020). At the end of the test, item and test analyses were performed and item difficulty level, standard deviation, indices of discrimination and independent group *t*-test analyses were calculated for lower and upper group segments. Finally, the KR-20 reliability value of the test was found to be .85, revealing that the prepared measuring tool was valid and reliable.

Mathematics attitude scale

In order to determine the attitudes of learners toward mathematics, we used the Mathematics Attitude Scale, which was adapted by Lim and Chapman (2013). The validity, reliability and adaptation of the 17-item scale, which covers general mathematics topics, were determined by Hacıömeroğlu (2017). The Cronbach alpha value of the scale applied for this sample was .88, .86, and .81, respectively, and the total score was .84.

Semi-structured interview form

A semi-structured interview form was created using the relevant literature to examine the learners'

detailed views regarding differentiated instruction. In this context, four open-ended questions were prepared regarding the learners' general idea on differentiated instruction, their opinions about the process, its applicability to other topics in mathematics class such as numbers, algebra and geometry, and their problems within this process. The form was submitted to obtain the opinions of two experts – one in the mathematics field and the other in the qualitative research field.

Examples of the questions on the form are as follows: "What do you generally think about the differentiated education applied in mathematics lesson?"; "Do you experience any problems during the application of differentiated instruction? If so, can you explain?"

Teaching in the Experimental Group Based on Differentiated Instruction

Operations with fractions presented through differentiated instruction was planned for the experimental group. During the preliminary preparation phase of the teaching process we prepared the lesson plans on the learning gains that had been determined beforehand and the materials to be used in the lesson (activities, worksheets). These lesson plans and materials were submitted to three experts on mathematics teaching, two experts on assessment and evaluation and one expert on differentiated instruction to obtain their opinions in this regard. Changes and arrangements were made based on their suggestions. In the following stage, a tiered instruction strategy using differentiated instruction was applied to the experimental group (Pierce & Adams, 2004). Firstly, the teaching processes for operations with fractions were determined. Learners participating in the study were divided into different groups according to their level of readiness, which was determined using short-answer responses to measure the learners' prior knowledge (Kokkinos & Gakis, 2021; Prast et al., 2018). Those learners who achieved zero to three out of 10 questions in the short-answer test correct were regarded to be at a low level; those who had four to seven correct were determined to be at a medium level and those who had more than eight correct were determined to be at a high level. Thus, the groups in which the learners would be divided differed according to the learners' answers to the short-answer questions (Awofala & Lawani, 2020; Tieso, 2003).

In the activity phase, the class was divided into two groups of learners at low and medium levels. The learners on the low level worked with simple fractions (requiring multiplication but not division) and concrete fraction blocks; learners at the medium level worked with pictorial or symbolic activities involving more conceptual operations (where numerators and denominators might be multiplied or divided) to create equivalent fractions and more challenging questions were asked.

In the following stage of the implementation, short-answer responses were conducted to determine the learners' prior knowledge of the new subject before beginning to learn something different. As a result of diagnostic assessment, the readiness levels of the learners was determined and it was decided which learners would be divided into which groups (lower, middle, high). In addition, question-and-answer techniques were used to determine learners' prior knowledge and learning levels when necessary. Thus, the basic features of operations with fractions were explained in depth to all learners. At the end of each lesson, the learners' activities and worksheets were collected and evaluated and the required feedback was given to learners in the following lesson.

Traditional Teaching Process in Control Groups 1 and 2

While I presented traditional teaching in Control Group 1, it was applied by the mathematics teacher in Control Group 2. During the implementation of the traditional process, teaching was presented in line with the lectures, activities and examples given in the textbook; learners were required to solve problems in this context and lessons were conducted using the question and answer method. Issues that learners did not understand were repeated as required.

Data Collection

In the quantitative part of the research, the Mathematics Achievement Test and the Mathematics Attitude Scale were first applied as a pre-test. While the tiered instruction strategy of differentiated instruction was applied to the experimental group, the control group was taught the concepts from the textbooks in line with the available mathematics curricula. At the end of the experimental process, the Mathematics Achievement Test and the Mathematics Attitude Scale were applied to the experimental and control groups as a post-test. At the end of the study, semi-structured interviews were held with the learners in the experimental group to determine their own opinions on the qualitative data.

Data Analysis

During the study, quantitative analyses were conducted in IBM SPSS Statistics 25 (IBM Corp., 2017). One-way analysis of covariance was used to determine the significance of the mathematics achievement and attitude variable of the experimental and control groups, while a descriptive analysis technique was applied in the qualitative dimension of the study. Descriptive analysis can be prepared according to research questions or pre-determined themes, and it can also

form a frame for data analysis that is based on the dimensions within the interviews. The coded data were analysed and grouped depending on their similarities and differences, and subsequently placed in appropriate themes and presented as a summary chart (Creswell & Plano Clark, 2017). Direct quotations were also included in this process where necessary; in addition, to avoid indicating the learners' identities, female and male learners were referred to as F1, F2, M1, and M2 during the interviews.

To ensure the reliability of the semi-structured interviews that constituted the qualitative dimension of the study, the reliability value (Miles et al., 2020) between the two encoders was calculated in the analysis of the interview data, which resulted in a harmony ratio between the two encoders of .91.

Findings

The first sub-objective of the study was to determine whether there was a significant difference between the post-mathematics achievement scores when the learners' pre-mathematics achievement scores in the experimental group and the control groups were taken into account. The values related to the findings obtained for this sub-purpose are presented in Table 1.

Table 1 Group-based ANCOVA results of post-test scores corrected according to pre-test scores

Source	*SS*	*df*	*MS*	*F*	*p*	η2
Controlled variable: pre-test (regression)	132.689	1	132.689	8.22	.005	.09
Main effect of grouping	230.575	2	115.288	7.14	.001	.15
Error	1339.759	83	16.142			
Corrected total	1662.276	86				

I found a significant difference between the corrected average post-test scores according to the ANCOVA test results applied to the experimental group, Control Group 1 and Control Group 2 [$F_{(2-83)} = 7.14$; $p < .01$]. Accordingly, it is clear that differentiated instruction was effective in improving learners' mathematics achievement. The calculated value for the partial impact size is .15. Since this value is higher than .14, the effect size can be said to be wide (Cohen, 1988). According to the Bonferroni test results, the corrected average post-test scores of the learners in the experimental group ($\bar{X} = 12.09$) are significantly higher than the corrected post-test achievement scores of learners in Control Group 1 and Control Group 2 ($\bar{X}_1 = 8.89$; ($\bar{X}_2 = 8.38$). Accordingly, the average post-test achievement scores of the differentiated instruction applied to the experimental group learners differed significantly from the average post-test achievement scores of the learners in Control Group 2 in favour of the experimental group. However, the difference between the corrected average post-test scores of Control Group 1 and Control Group 2 was not statistically significant according to the Bonferroni test.

The second sub-objective of the study was to determine whether there was a significant difference between the post-test mathematics attitude scores when the experimental group and the control group learners' pre-test mathematics attitude scores were taken into account. These results are presented in Table 2.

Table 2 Group-based ANCOVA results of post-test scores corrected according to pre-test scores

Source	*SS*	*df*	*MS*	*F*	*p*	η2
Controlled variable: pre-test (regression)	2387.265	1	2387.265	15.014	.000	.153
Main effect of grouping	62.463	2	31.232	.196	.822	.005
Error	13196.872	83	158.998			
Corrected total	15681.057	86				

Table 2 reveals that there was no significant difference between the corrected average post-test scores in accordance with the ANCOVA test when the groups' pre-test scores of the mathematics attitude scale were taken into account [$F_{(2-83)} = .196$; $p = .82 > .05$]. In other words, post-mathematics attitude scores of all groups were very close to each other.

The final sub-objective of the study was to determine what the learners in the experimental group thought about differentiated instruction. The data obtained from the learners' opinions on differentiated instruction are shown in Table 3.

Table 3 Distribution of data on learners' opinions about differentiated instruction

Theme	Codes	Sub-codes	Learner codes	*f*
General opinion	Learning environment	Individual differences are taken into consideration	F1, F3, F6, F9, F10, M3, M4	7
		Learners take an active role	F2, F3, F6, F8, M2, M4	6
		Democratic educational environment is offered	F1, F5, F7	3
		Collaborative learning environment is provided	F1, F8	2
		Communication between learners increases	F6	1
	Cognitive dimension	Success increases	F1, F2, F3, F4, F6, F7, F8, M1, M2, M4, M5	11
		The subject is understood in depth	F1, F4, F5, F6, M1, M2, M5	7
		Lessons are efficient	F3, F4, F6, M5	4
	Affective dimension	Interest increases	F2, F3, F6, F8, F10	5
		Motivation increases	F8	1
Differences from current teaching	In terms of teacher	Number of activities and materials increases	F2, F5, F6, F7, F10	5
		Number of counselling activities increases	M2	1
	In terms of teaching process	Individual differences of learners are taken into consideration	F1, F3, F5, F6, F7, M2, M4, M5	8
		Active participation in the lesson increases	F2, F6, F8, M2, M4	5
	In terms of learner	Different materials are used	F4, M4	2
		Lesson is more interesting	M2	1
Applicability	Always	Applicable	F2, F3, F8, M1, M2	5
	Sometimes	Subject-related situations	F4, F5	2
		Lesson duration related situations	F9	1
Encountered problems	In terms of learner	The problems encountered in the context of creating groups	F1, F2, F8, M3, M4, M5	6
		The problems encountered in distribution of tasks	F1	1
	Environment	Educational environment is crowded and noisy	F7	1

The learners' responses about differentiated instruction are presented under four main themes in Table 3: general view, different aspects from the current teaching method, applicability, and encountered problems. In the first theme the learners' general views were gathered under three codes: learning environment, cognitive dimension, and affective dimension. Regarding the learning environment code, almost half of the learners stated that individual differences were taken into account and that learners took an active role. Again, under the same code, three of the learners stated that a democratic environment was provided, two of them stated that a collaborative learning environment was provided, and one learner stated that the communication between learners had improved. In the cognitive dimension code, the majority of learners stated that the differentiated instruction had increased their achievements and that they understood the subject in greater depth, and four other learners stated that the course was efficient. In the affective dimension code, five of the learners stated that their interest had increased and one of them indicated that their motivation had increased. For example, F3 said the following: "*... everyone studied with their group in the classroom ... I was never bored….*"

When the views of the learners on the different aspects of the differentiated instruction as opposed to the current teaching methods were examined, the differences were grouped under three main codes: teacher, learning and teaching process, and learners. In the teacher code, one third of the learners stated that the number of activities and materials had increased and one learner stated that the counselling activities had increased. In the learner code, five of the learners stated that the active participation in the course had increased and one of them indicated that the course was interesting. For example, Learner M2 stated that "*we understand the subject very well when the teacher explains it easily*."

When the learners were asked if the differentiated instruction could be applied to subjects other than mathematics, one third of the learners stated that it could always be applied, and other learners stated that it could sometimes be applied depending on the subject and the duration of the course. Learner M1 stated that "*... it is time*

consuming but I think it can also be applied to other subjects that we do not understand."

When the learners were asked about the problems they had encountered during the implementation of the differentiated instruction, the learners stated that they encountered problems in the distribution of tasks during the creation of groups and during the group study process. In this context, Learner M5 stated that "*... everyone in the group wants to be head of the group…. We also have some friends who do not want to perform their duties in the group….*"

Discussion

Like all developing countries, Turkey gives great importance to education and training policies. Of late, various perspectives, in-service training activities and seminars have been developed in an effort of continuously update teaching programmes. Recent mathematics curricula underline that teachers should design their own differentiated instruction by considering learners' individual differences such as different levels of readiness, different learning abilities and different achievement levels. However, the results of the international exams such as PISA emphasise that despite the growing international success of Turkey, the desired level of success in the field of mathematics has not been achieved (Avvisati et al., 2019). Especially in the context of mathematics lessons, it is seen that differentiated instruction is theoretically not at the desired level in classroom practices (Afurobi et al., 2017; Melesse, 2015). In this context, the aim of this study was to assess the impact of differentiated instruction in terms of mathematics achievement and the attitudes of secondary school learners and reveal their views on differentiated instruction. We conclude that the final achievement test scores of learners in the experimental group (in which differentiated instruction was applied) were higher compared to those of the learners in the control group. This result is supported by the results of many similar studies in which differentiated instruction has been applied (Awofala & Lawani, 2020; Chamberlin & Powers, 2010; Özer & Yilmaz, 2018; Prast et al., 2018; Smale-Jacobse et al., 2019). In their experimental study conducted in 2019, Smale-Jacobse et al. conclude that differentiated instruction made a significant difference in favour of the experimental group in the context of mathematics achievement.

Within the scope of the relevant literature, some findings are dissimilar to the results presented here (Millikan, 2012; Pablico, Diack & Lawson, 2017). For example, Pablico et al. (2017) conclude that differentiated instruction does not result in any statistical difference in terms of learners' scores. Millikan (2012), in his study carried out on high school learners, also found that differentiated instruction only had a small effect on learners' achievement within an algebra course. The reason for the difference between the results of this study and the results of the studies above may be due to the study group, the teacher, or the content of the subject.

From this, it can be said that the learners in the experimental group had similar attitudes towards mathematics before and after the differentiated teaching process. This result is supported by the results of similar studies in which differentiated instruction was applied (Deringöl & Davaslıgil, 2020; Özer & Yilmaz, 2018; Ugurel, 2018). However, there are other studies in the literature that point to different results (Senturk & Sari, 2018). For example, Senturk and Sari (2018) concluded that learners have a positive attitude towards differentiated instruction. The reason for the difference between the results of this study and the results of the studies above may be due to the study group that participated in the study, the duration of the study, and/or the different content.

In the third sub-purpose of this study, the learners in the experimental group were asked to give their opinions about classroom practices regarding differentiated instruction. The answers to these questions reveal that, in general, individual differences are taken into consideration in differentiated instruction, that success, interest and motivation are increased, and an active and cooperative democratic education environment is provided. These results are similar to the findings from other studies (Gong & Gao, 2018; Pablico et al., 2017; Sondergeld & Schultz, 2008). Small (2017) concludes that mathematics curricula should be rearranged in such a way so that it responds to learners' individual interests, needs, and intelligence. Also, Gong and Gao (2018) conclude that differentiated instruction is an educational approach that increases individual learners' learning and motivation.

Learners were asked about the applicability of differentiated instruction to other subjects, besides mathematics. One third felt that differentiated instruction should only be applied to mathematics courses, and the others felt that differentiated instruction could also be applied to other subjects. This result is partially in line with other literature (Afurobi et al., 2017; Melesse, 2015; Ugurel, 2018). Ugurel (2018) concludes that differentiated instruction can be applied effectively in physics and in other subjects. Similarly, Sondergeld and Schultz (2008) demonstrate the applicability of differentiated instruction to all courses in their studies.

Finally, the learners who participated in this study were asked about their views regarding the problems encountered in classroom practice regarding differentiated instruction. Learners stated that they had problems in terms of grouping,

distribution of tasks, and the environment. Similarly, previous studies have reported similar results (Melesse, 2015; Sondergeld & Schultz 2008; Ugurel, 2018). As a result of the phenomenological research they conducted in order to determine how differentiated instruction was perceived by teachers, Melesse (2015) concludes that teachers had problems due to not having sufficient information about the learners and the approach.

Conclusion

Secondary school learners conventionally vary in academic abilities and achievement levels. An important factor for this diversity is to differentiate the curriculum according to learners' individual needs. Thus, as a result of the increase in learner diversity in the classroom, the need for teaching strategies such as differentiated instruction is increasing. This is in line with socio-constructivist theories enhancing the zone of proximal development (Vygotsky, 1978) which emphasises that educational needs vary based on achievement levels and that adapting education to those different needs leads to more effective learning. In light of these theoretical facts and considering the above-mentioned results and findings, it is concluded that in the Turkish context, with the implementation of the differentiated instruction, learners' academic achievement and their interest in the lesson had increased – especially in mathematics in which learners' achievement was low. Furthermore, it is also concluded that differentiated instruction does not make any significant difference in the attitudes towards mathematics of Grade 5 secondary school learners in Turkey. The fact that this study was conducted only among Grade 5 secondary school learners and in the sub-learning field of fractions, can be regarded as a limitation of the study. However, with future studies the efficiency of differentiated instruction at other secondary school grade levels and in different sub-learning fields such as numbers, algebra, and geometry can be measured.

Notes

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