Journal name	International e-Journal of Educational Studies
Abbreviation	IEJES
e-ISSN	2602-4241
Founded	2017
Article link	http://doi.org/10.31458/iejes.1238841
Article type	Research Article
Received date	18.01.2023
Accepted date	11.03.2023
Publication date	21.03.2023
Volume	7
Issue	13
pp-pp	170-179
Section Editor	Prof.Dr. Suat ÜNAL
Chief-in-Editor	Prof.Dr. Tamer KUTLUCA
Abstracting & Indexing	EBSCO Education Full Text Database Coverage List H.W. Wilson Index Copernicus DRJI Harvard Library WorldCat SOBIAD
Article Name	Teaching of Solid, Liquid and Gas Substances to Students with Intellectual Disabilities through Direct Instruction Method

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Conceptualization, literature review, methodology, implementation, data analysis, translation, and writing

Abstract

The aim of this study is determine the effectiveness and usefulness of direct instruction method in teaching certain "solid, liquid and gas" substances to students in a special education classroom in secondary school. The study was carried out through the case study that is one of the qualitative research methods. The teaching method used in order to test the efficiency of the study is the direct teaching method. Four students with intellectual disabilities participated in the study. One of the students was female (14 years old) while other students were male (15, 10, 10 years old). Three students had moderate disability and one had mild disability. In this study, the data were collected through semi-structured interviews and non-structured observations. Semi-structured interviews were conducted with the implementation teacher. Data obtained through interviews and observations in the study was analysed using qualitative data analysis approach and content analysis was performed on the data. Semi-structured interviews with the teacher were transcribed and analyzed. At the end of the study, it was found that three students learned all of the solid, liquid and gas substances that were taught to them and achieved permanent learning while one of the students learned solid, liquid and gas substances but did not achieve permanent learning for gas substances. Thus, it was concluded that direct instruction is an effective and useful method for teaching solid, liquid and gas substances to students with intellectual disabilities.

To cite this article:

Çapraz, C. (2023). Teaching of solid, liquid and gas substances to students with intellectual disabilities through direct instruction method. *International e-Journal of Educational Studies, 7* (13), 170-179. https://doi.org/10.31458/iejes.1238841

Research Article

Teaching of Solid, Liquid and Gas Substances to Students with Intellectual Disabilities through Direct Instruction Method *

Cüneyt ÇAPRAZ [1]

Abstract

The aim of this study is determine the effectiveness and usefulness of direct instruction method in teaching certain "solid, liquid and gas" substances to students in a special education classroom in secondary school. The study was carried out through the case study that is one of the qualitative research methods. The teaching method used in order to test the efficiency of the study is the direct teaching method. Four students with intellectual disabilities participated in the study. One of the students was female (14 years old) while other students were male (15, 10, 10 years old). Three students had moderate disability and one had mild disability. In this study, the data were collected through semi-structured interviews and non-structured observations. Semi-structured interviews were conducted with the implementation teacher. Data obtained through interviews and observations in the study was analysed using qualitative data analysis approach and content analysis was performed on the data. Semi-structured interviews with the teacher were transcribed and analyzed. At the end of the study, it was found that three students learned all of the solid, liquid and gas substances that were taught to them and achieved permanent learning while one of the students learned solid, liquid and gas substances but did not achieve permanent learning for gas substances. Thus, it was concluded that direct instruction is an effective and useful method for teaching solid, liquid and gas substances to students with intellectual disabilities.

Keywords: Intellectual disabilities, science teaching, direct instruction, states of matter

1. INTRODUCTION

Individuals with intellectual disabilities lack necessary education to assume responsibility for their lives, to make choices and decisions and participate in the society actively (Avşar-Tuncay & Kizilaslan, 2022). In this case, they have difficulty in accessing knowledge, and thus, they cannot become productive and independent individuals, show active participation in social life or have a proper job (American Psychological Association (APA), 2013). Individuals with Disabilities Education Act that was first passed in 1974 in the USA and changed its name to I.D.E.A. in 1990 defends the education right of all individuals with disability (Jackson, 2005). That is because, intellectually disabled individuals who receive sufficient education will have no problems in making decisions, achieving personal independence and increasing the quality of their lives and prove more successful in social life (Ministry of National Education [MoNE], 2008).

Individuals with intellectual disabilities undergo the same cognitive processes with those without intellectual disabilities. However, in all these cognitive processes, these persons go through different stages than their peers (MoNE, 2008). Like their non-disabled peers, they can learn and continue their learning. However, they differ from their non-disabled peers in learning speed as they learn more slowly (Kizilaslan, Sözbilir & Zorluoğlu, 2020). They have difficulty in reading-writing, reading comprehension and acquiring basic arithmetic skills (APA, 2013; MoNE, 2008). They learn concrete concepts or topics more easily than abstract concepts or topics (MoNE, 2008).

Received Date: 18/01/2023 **Accepted Date:** 11/03/2023 **Publication Date:** 21/03/2023

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The percentage of the population with a disability is 12.29% within the total population. The percentage of individuals with orthopaedic, visual, hearing, language, speech and mental disabilities is 2.58%, that is, approximately 1.8 million. When considering the distribution of number of students receiving education at special education schools, special education classrooms and inclusive classes by years according to the data provided by the Ministry of National Education, a significant increase is seen. While the number of students receiving education in 2001-2002 was 53.306, this number became 353,610 by increasing approximately 7 times. Of the students receiving education at private education institutions, when comparing those enrolled at special education schools, special education classrooms and inclusive classes, most of these students receive education at inclusive classes. As to 2017-2018 school year, of all students receiving education, 72.9% of them have education at inclusive education, 13% are in special education classes and 14.1% are enrolled at special education schools. In the statistics published by the Ministry of National Education in 2018-2019 school year, a total of 2.222 mentally disabled students, 814 of whom were at primary and 1.408 were at secondary schools, were receiving education. When considering this data, the importance of science education to be provided and the contribution it will make to these individuals are clear. Science education provides a conceptual and theoretical basis for these individuals to access necessary knowledge, understand and interpret what is happening around them and adapt into these situations (MoNE, 2008). In addition, science education is highly important for intellectual and creative development (İşman, Baytekin, Balkan, Horzum & Kıyıcı, 2002).

Countries with advanced education have adopted “science for individuals” approach in science education. According to the National Science Education Standards (NSES) by the U.S. National Research Council (NRC), all students need science education regardless of age, gender, cultural or ethnic background, disabilities, interest and motivation (NRC, 1996). United Nations Educational, Scientific and Cultural Organization’s (UNESCO) Salamanca Statement declares that every child has a right to education (UNESCO, 1994). In this context, underscoring the significance of increasing students' interest in science and of science education, the statement stresses that science education is necessary for everyone. In line with this understanding, Türkiye started to implement a student-centred education approach in 2005 (Toraman & Aydın, 2013). The vision of science course was determined as training all students to be individuals with scientific literacy regardless of individual differences (MoNE, 2018).

The main aim of current science curricula is raising individuals with scientific literacy (American Association for the Advancement of Science’s (AAAS), 1993). In line with this aim, individuals will have scientific literacy and can learn scientific topics, concepts, laws and principles. At the same time, they can become aware of the nature of science and scientific developments, and understand the relationship between technology, science and environment. Having scientific literacy will also help people to lead their lives in a more fertile and satisfactory environment (Köseoğlu et al., 2003). Furthermore, science is an activity that enriches children's lives. People at all ages have an innate curiosity for observation and exploration through which they take pleasure. The sooner such curiosity and pleasure are aroused, the better it is for them (Yıldırım, 2011). It is seen in the program issued by the Ministry of National Education in 2018 on the compulsory and elective courses to be given to the individuals with mild mental disability at the schools affiliated to the ministry that the weekly compulsory course hours of science education was three as of the third grade of primary school while it was 4 at secondary schools. The elective course hour was 2 at both primary and secondary schools. The weekly course hour of science to be received by the students with mental disability and healthy students is similar. In this regard, these individuals follow the same curriculum with their healthy peers. However, although science education is of importance for students with intellectual disabilities, most of them cannot receive sufficient science education (Mete, Çapraz & Yıldırım, 2017). This is caused by shortcoming and insufficiency in educational opportunities used

for these individuals. When considering the weekly hour of compulsory science course and the number of students enrolled at both special education classrooms and inclusive classes, this resulted in the studies that must be carried out for these students related to science course. Because it has been concluded that the mentally disabled students have not been provided with an effective science education in both literature review and the observations made at schools. When considering all this data, the significance of science education to be given to these students is of paramount importance (Çapraz, 2016; Çapraz & Boynikoğlu, 2021; Mete, 2016).

It is seen that studies in literature on the impact of teaching methods that can be used in science course on student success are very few (İlik, 2009). Among studies on individuals with intellectual disabilities that were conducted in Türkiye, only three of them are directly relevant to science education. The subjects addressed in these studies include organs in digestive system (Demir, 2008); solar system and planets (İlik, 2009) and hard-soft substances (Mete, 2016). We have found no study on teaching solid, liquid and gas matters to these students through direct instruction. This study aims to determine the effectiveness and usefulness of direct instruction method in teaching certain "solid, liquid and gas" substances to students with intellectual disabilities in a special education classroom in secondary school. It is considered that the study will contribute to teaching scientific concepts to students with intellectual disabilities using teaching materials so that they can take responsibility for their lives, make choices and decisions, actively participate in the society, and grow up to be individuals with scientific and technological literacy depending on their disability.

2. METHOD

This study was designed as a case study, a qualitative research approach. Of the case study designs, the holistic multiple case was utilised based on the classification made by Yin (2013). In this design, holistic multiple cases can be seen. Each case is evaluated holistically and then compared with each other (Yildirim & Simsek, 2018). The teaching method to be used in order to test the efficiency of the study is the direct teaching method. Direct instruction is a teaching method in which teacher is responsible for the learning of all students and plays an active role while students are more passive compared to the teacher. The teacher helps students to learn accurately by rewarding students when they become successful in learning, and by doing or demonstrating the accurate performance when they fail (Mastropieri & Scruggs, 2016). It is also an effective model for students with different learning needs (Kinder, Kubina & Marchand-Martella, 2005). As distinct from other instruction methods, the content of curriculum can be organized in direct instruction (Mastropieri & Scruggs, 2016). Direct instruction is also called systematic instruction, explicit instruction and active instruction (Çelik & Vuran, 2008). In the implementation stage of the study, three initial sessions were held with each student to show each substance and its photo before starting teaching. With instructions like "Look at the substance and tell us in which state it is." and "Look at substances on the desk. Show us which one is solid/fluid/gas.", these sessions aimed at identifying whether the students knew these substances. To teach the substances, the steps in direct instruction (setting the stage, modelling for students, guided practice and independent practice) were implemented in the instruction sessions. The experimenter followed these steps during instruction and when the student was stuck in a step, he returned to the previous step and repeated teaching. When the student completed these stages successfully, teaching was ended. In other words, instruction session ended when the student told/showed the physical state of the relevant substances correctly at the end of these steps. Following the instruction sessions, the experimenter assessed whether the student learned the substance that was taught in a monitoring session at the end of the day, and teaching of the next substance started for the student who became successful in the end of day session. For each substance that was taught, monitoring sessions were held for 1, 2 and 4 weeks later (7th, 14th and 30th days). Monitoring

sessions assessed whether the students still had the knowledge of substances that were taught to them. The implementation process is summarized below.

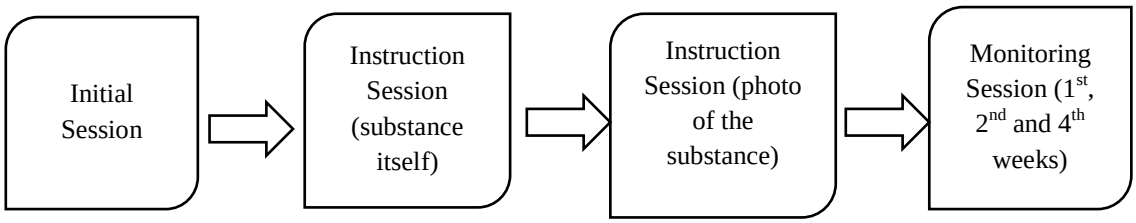

Figure 1: Implementation process

2.1. Sampling Selection

Criterion sampling method, a purposive sampling technique, was used in sampling selection for the study. Purposive sampling allows in-depth studies in cases that abundant data can be collected. (Teddlie & Yu, 2007). On the other hand, criterion sampling is used to study cases that meet a predetermined criterion. Criteria can be set by the researcher or pre-specified criteria can be used (Büyüköztürk, 2014; Teddlie & Yu, 2007). The solid, liquid, gaseous substances were not previously taught to the students in the study group by the direct teaching method. In other words, the participants did not have any previous systematic education by direct teaching method.

The following criteria were used in the selection of the working group;

1) Following verbal instructions,
2) Being capable of taking someone as model,
3) Focusing attention on an activity at least for 5 minutes,
4) Keeping knowledge in mind,
5) Using hands and fingers,
6) Attending the school on a regular basis (Çelik & Vuran, 2008; İlik, 2009).

To identify whether the subjects met the prerequisite skills, classroom observation was carried out for 2 hours a day in a week for 10 weeks, which corresponds to a total of 20 hours. In addition, interviews were conducted with a special education teacher. Through these observations and interviews, it was concluded that the students had the abovementioned prerequisite skills.

2.2. Participants

The sample of the study consisted of four students with intellectual disabilities who were taking courses in a special education class in a school in Erzurum, Türkiye. One of the students was female (14 years old) while other students were male (15, 10, 10 years old). Three students had moderate disability and one had mild disability. One of the boys (Student-1) had a second disability, visual disability (not seeing enough). Another male student (Student-2) was autistic while another one (Student-3) had chronic epilepsy. The students were in the 5th and 6th grades.

2.3. Data Collection Methods and Data Analysis

In this study, the data were collected through semi-structured interviews and non-structured observations. Semi-structured interviews were conducted with the implementation teacher. For these interviews produced a semi-structured interview form with 34 questions. 15 questions were asked to the teacher before the implementation and 19 questions after the implementation. Interview questions were given to the teacher and the teacher was asked to write down the answers. Data obtained through interviews and observations in the study was analysed using qualitative data analysis approach and content analysis was performed on the data. Semi-structured interviews with the teacher were transcribed and analyzed. The researcher and one colleague independently examined the interviews,

and the results were compared. A concordance of more than 80% was found between the analyzes of both researchers. The inconsistencies that emerged in this process were discussed and resolved, and the analysis of the interview data was completed. To determine the effectiveness and permanence in education, data obtained through criterion dependent measurement tools and observations and interviews was analysed, reported and presented in the findings section.

3. FINDINGS

3.1. Findings on the Effectiveness and Usefulness of Direct Instruction

The findings on the effectiveness and usefulness of education using individualized education materials that were prepared based on direct instruction of solid/fluid/gas substances for students with intellectual disabilities are presented in tables. In the tables, outcomes concerning initial sessions demonstrate students' learning after three sessions. The outcomes concerning instruction sessions display learning status after the sessions. However, the number of instruction sessions varies based on the student's learning. When the student told/showed the physical state of the matter in question correctly, an instruction session was ended. For example, while the student-1 learned in seventh instruction session that stone is a solid substance (Table 1), the same student learned that air is in gas state in third session (Table 1). As for outcomes on monitoring sessions in the tables (Table 1-4), "+" is used to show that learning is permanent for those who gave correct answers to the instructions in all these sessions. However, "-" is used to refer to cases in which no correct answer was given in the monitoring sessions.

Table 1. Initial, instruction and monitoring sessions and correct responses/learning status of the student-1

Item	**Itself**				**Picture**			
Solid	IS	NIS	LS	MS	IS	NIS	LS	MS
Stone	-	7	+	+	-	1	+	+
Pencil	-	3	+	+	-	1	+	+
Book	-	2	+	+	-	1	+	+
Spoon	-	2	+	+	-	1	+	+
Glass	-	2	+	+	-	1	+	+
Liquid								
Water	-	6	+	+	-	1	+	+
Milk	-	1	+	+	-	1	+	+
Juice	-	2	+	+	-	1	+	+
Olive Oil	-	2	+	+	-	1	+	+
Tea	-	2	+	+	-	1	+	+
Gas								
Air	-	3	+	+	-	1	+	+
Vapor	-	6	+	+	-	2	+	+

IS: Initial Sessions (Pre-Teaching) NIS: Number of Instruction Sessions LS: Learning Status
MS: Monitoring Sessions (1st, 2nd and 4th weeks) +: Positive Outcome -: Negative Outcome

While the student-1 did not know any of the substances in the initial sessions, he learned the physical state of the substances thanks to the instruction sessions conducted with the substance itself and its photo (Table 1). The student's learning took place in varying number of sessions. For example, while the student learned that stone is solid after seven sessions using the substance itself, he learned that glass, metal spoon and book are solid substances after two sessions. On the other hand, he learned that water and milk is fluid in six sessions and one session, respectively, which is remarkable. It is also interesting that he learned that steam and air are in gas state in six and three sessions, respectively

(Table 1). While he learned in two sessions that steam is gas through teaching using photos following the use of substances themselves, he learned other substances in one session. It was found in the monitoring sessions held after instruction that the student achieved permanent learning for all the substances (Table 1).

Table 2. Initial, instruction and monitoring sessions and correct responses/learning status of the student-2

Item	**Itself**				**Picture**			
Solid	IS	NIS	LS	MS	IS	NIS	LS	MS
Stone	-	1	+	+	-	1	+	+
Pencil	-	1	+	+	-	1	+	+
Book	-	1	+	+	-	1	+	+
Spoon	-	1	+	+	-	1	+	+
Glass	-	1	+	+	-	1	+	+
Liquid								
Water	-	1	+	+	-	1	+	+
Milk	-	2	+	+	-	1	+	+
Juice	-	1	+	+	-	1	+	+
Olive Oil	-	1	+	+	-	1	+	+
Tea	-	1	+	+	-	1	+	+
Gas								
Air	-	2	+	+	-	1	+	+
Vapor	-	1	+	+	-	1	+	+

IS: Initial Sessions (Pre-Teaching) NIS: Number of Instruction Sessions LS: Learning Status
MS: Monitoring Sessions (1st, 2nd and 4th weeks) +: Positive Outcome -: Negative Outcome

As in the student-1, student-2 also did not know any of the substances in the initial sessions (Table 2). While the student-2 learned that milk is fluid and air is gas after two instruction sessions; he learned the physical states of other materials after one instruction session (Table 2). He learned the physical forms of the substances in an instruction session using the photo of the substance in question. In the monitoring sessions, it was found that the student achieved permanent learning for all the substances.

Table 3. Initial, instruction and monitoring sessions and correct responses/learning status of the student-3

Item	**Itself**				**Picture**			
Solid	IS	NIS	LS	MS	IS	NIS	LS	MS
Stone	-	4	+	+	-	1	+	+
Pencil	-	1	+	+	-	1	+	+
Book	-	2	+	+	-	1	+	+
Spoon	-	1	+	+	-	1	+	+
Glass	-	1	+	+	-	1	+	+
Liquid								
Water	-	2	+	+	-	1	+	+
Milk	-	1	+	+	-	1	+	+
Juice	-	1	+	+	-	1	+	+
Olive Oil	-	1	+	+	-	1	+	+
Tea	-	1	+	+	-	1	+	+
Gas								
Air	-	5	+	-	-	2	+	-
Vapor	-	1	+	-	-	1	+	-

IS: Initial Sessions (Pre-Teaching) NIS: Number of Instruction Sessions LS: Learning Status
MS: Monitoring Sessions (1st, 2nd and 4th weeks) +: Positive Outcome -: Negative Outcome

Like the student-1 and student-2, student-3 failed in telling the physical state of any of the substances in the initial sessions (Table 3). During the instruction sessions using the substances themselves, he learned that air is gas, stone is solid and book is solid in five, four and two sessions, respectively while he learned the physical states of other substances in a single session (Table 3). In instruction using photos, the student who learned in two sessions that air is gas learned other substances in one session. However, it was found that the student-3 achieved permanent learning for solid and fluid substances while he failed in learning gas substances.

Table 4. Initial, instruction and monitoring sessions and correct responses/learning status of the student-4

Item	**Itself**				**Picture**			
Solid	IS	NIS	LS	MS	IS	NIS	LS	MS
Stone	-	3	+	+	-	1	+	+
Pencil	-	2	+	+	-	1	+	+
Book	-	2	+	+	-	1	+	+
Spoon	-	1	+	+	-	1	+	+
Glass	-	2	+	+	-	1	+	+
Liquid								
Water	-	1	+	+	-	1	+	+
Milk	-	1	+	+	-	1	+	+
Juice	-	1	+	+	-	1	+	+
Olive Oil	-	1	+	+	-	1	+	+
Tea	-	1	+	+	-	1	+	+
Gas								
Air	-	1	+	+	-	1	+	+
Vapor	-	2	+	+	-	1	+	+

IS: Initial Sessions (Pre-Teaching) NIS: Number of Instruction Sessions LS: Learning Status
MS: Monitoring Sessions (1st, 2nd and 4th weeks) +: Positive Outcome -: Negative Outcome

According to Table 4, the student knew none of the substances in the initial sessions while he learned these substances in the instructions sessions using the physical substances and their photos. While he learned that stone is solid after three sessions, he learned after two sessions that pencil, book and glass are solid substances. He also learned in two sessions that steam is gas. Monitoring sessions identified that he achieved permanent learning for all the substances. The tables summarize the findings on whether the students knew or learned solid, fluid and gas substances and achieved permanent learning after the 1st, 2nd and 4th weeks in the initial, instruction and monitoring sessions. None of the students who participated in the study had pre-learning of the substances in solid/fluid/gas states. Following instruction, each student learned the substances that were taught using the substances themselves and their photos although the number of sessions differed for everybody. It was found in the monitoring sessions that student-1, student-2 and student-4 achieved permanent learning for all the substances that were taught using the substances themselves and their photos. However, while the student-3 achieved permanent learning for solid and fluid substances in the monitoring sessions, he did not make positive statements in any of the three monitoring sessions for gas substances.

4. DISCUSSION and CONCLUSION

This study aimed at determining the effectiveness and usefulness of direct instruction in teaching "solid, liquid and gas" substances to four students with intellectual disabilities. To that end, certain substances in solid, fluid and gas states were taught to the students. The study investigated the effectiveness and usefulness of direct instruction method in education as well as permanence of learning by assessing whether the substances taught using this method were remembered after 7, 14 and 30 days. When the data obtained from the study conducted on 4 students was analysed, it was

found that none of the students knew the states of the substances taught before instruction, and every student learned after instruction that the substances were in solid, fluid or gas states. It is natural that the students displayed similar performances in learning as their disability type and level as well as level of education were similar or close (Strickland, 2011; Türer, 2010). Another study indicating that direct instruction method is effective in the education of persons with intellectual disabilities was conducted by İlik (2009). The study found that direct instruction method was effective for all the subjects in teaching solar system in science course to students with mild learning difficulty.

When the findings of the study were analysed, it was seen that direct instruction was an effective method for teaching solid, fluid and gas matters to the students who participated in the study with enough time and using appropriate educational tools. The reason for success results in teaching solid, fluid and gas substances using direct instruction is that the topic was taught in a couple of steps, the help students received was decreased gradually and responsibility for learning passed to the students and thus, the students actively participated in each step of education and made minimum number of mistakes with the help of teacher (Türer, 2010). During instruction, the same steps were followed for each educational objective. Thus, the student needed teacher support less in the following learnings. In addition, as teaching was carried out in the classroom, other students may have been influenced positively when one of them was learning. Indeed, previous studies revealed that the most significant aspect that separated children with disabilities from their non-disabled peers was the difficulties they experienced in learning (Şahbaz, 2005) and frequent repetition allowed students to remember the subjects that were taught more easily in the assessment of teaching (Aruk, 2008). The study indicated that student-1, student-2 and student-4 achieved permanent learning in the monitoring sessions for all the substances that were taught to them. (Table 1, Table 2, Table 4). However, the student-3 recalled solid and fluid matters in all the monitoring sessions while he did not gave positive responses for the gas matters in any of the monitoring sessions (Table 3). The reason for that may be the students' active participation in teaching process and having the opportunity to repeat the subject while one of them was learning. Besides, individual activities may affect the attention time of the individuals with intellectual disabilities (Çetin, 2011). The reason for failing in achieving permanent learning by one student (student-3) may be that these students' attention time is not very long, they cannot keep information in mind for long and they may lose interest in the material (Ahmetoğlu, 2004; Çetin, 2011). Direct instruction is an effective and useful method in learning and remembering solid, fluid and gas matters for each student who participated in the study. This method enables the student to achieve the objectives of the course (Watkins & Slocum, 2004). There are various studies in literature that support the findings on the effectiveness and usefulness of direct instruction method. In a study on teaching the names of vegetables to three preschool children with Down Syndrome through direct instruction method, Batu (2006) found that direct instruction method proved effective in teaching the names of vegetables to children with Down Syndrome and the subjects remembered such knowledge in the monitoring sessions held after four and five weeks. In a study conducted by Mete (2016), certain hard and soft substances were taught to students with intellectual disabilities through direct instruction method in the context of visible and perceivable properties of substances. At the end of the study, it was found that two of the three students in the sampling learned and remembered the subject, but one student did not deliver expected result in learning. In this study, the student who did not have pre-learning in the initial level learned all the substances in solid, fluid and gas states after teaching through direct instruction method and achieved permanent learning in the monitoring sessions to a considerable extent. These findings indicate that direct instruction method is effective and useful in teaching substances in solid, fluid and gas forms to students with intellectual disabilities in special education classroom in secondary school.

5. RECOMMENDATIONS

It was found that direct instruction is an effective and useful method in teaching substances in solid, fluid and gas forms to students with intellectual disabilities. Furthermore, this method ensured permanent learning and increased academic achievement as it did not allow mislearning in students. Therefore, this method can be recommended for teaching solid, fluid and gas substances and other topics in science course or in other courses in special education classrooms or mainstreaming classrooms. In addition, the following recommendations can be made:

- The implementation stage of the study was limited with 11 weeks and 10 materials. The substances that was aimed to be taught in a short time was taught with an intensive program. Therefore, longer studies on science education can be conducted using different substances and materials.
- In Türkiye, adequate importance is not given to science education for persons with special needs. However, as is seen in the studies conducted so far, such individuals can learn certain scientific topics and concepts. Thus, there is a need for studies on science education for persons with special needs.

As part of the study, direct instruction method was used in education. However, there are various methods that can be used for science education for persons with special needs. By using other effective teaching methods, it is also possible to examine the effectiveness of teaching and usefulness of the method.

Acknowledgement

The data used in this study was confirmed by researcher that belongs to the year before 2020.

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