EXPLORING THE EFFECTIVENESS OF A MOBILE WRITING APPLICATION FOR SUPPORTING HANDWRITING ACQUISITION OF STUDENTS WITH DYSGRAPHIA

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ABSTRACT

EXPLORING THE EFFECTIVENESS OF A MOBILE WRITING APPLICATION FOR SUPPORTING HANDWRITING ACQUISITION OF STUDENTS WITH DYSGRAPHIA

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Handwriting is one of the most important and essential skills for both literacy and beyond. However, some students may have difficulty in writing. Dysgraphia, expressed as the disorder of written expression, is the state of writing skills being below the expected level of intelligence, age, and education of the student. The main purpose of the study is to examine the effectiveness of the mobile writing application for students with dysgraphia and to determine whether there is an improvement in writing skills of the students after using this application. A mixed method design was employed in this study. 11 students with dysgraphia were participated to the study. To sum up, the results of this study revealed: 1) Experts' views before the quasi-experimental design were very positive. The aspects need to be improved were modified before the experiment. 2) The mobile writing application contributed to acquire writing skills (letter, spells, and words) for students with dysgraphia. 3) Students' percentages of on-task durations were in a range of 80% and 100%. When the writing speed of students session by session were examined, there was an increase in all of them. The correct attempts of the students were increased session by session

and the number of incorrect attempts decreased. The line violation of the students tended to decrease session by session. The frequency of the third-degree clue tends to decrease the session by session while the other clue types seem to be at the same level or tend to increase 4) Special education teachers' views were positive about mobile writing application.

Keywords: Educational Technology, Specific Learning Disabilities, Dysgraphia, Mobile Technologies, Mobile Writing Application, Handwriting

ÖZ

DİSGRAFİ YAŞAYAN ÖĞRENCİLERİN YAZMA BECERİSİNİ DESTEKLEMEK İÇİN GELİŞTİRİLEN MOBİL BİR YAZMA UYGULAMASININ ETKİLİLİĞİNİN DEĞERLENDİRİLMESİ

Hopcan, Sinan
Doktora, Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü
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El yazısı, hem okuryazarlık hem de faklı alanlar için en önemli ve temel becerilerden biridir. Buna rağmen, bazı öğrenciler yazmada güçlükler yaşamaktadır. Yazılı ifadede bozukluk olarak ifade edilen disgrafi, yazma becerilerinin öğrencinin zekasına, yaşına ve aldığı eğitime göre beklenenden daha düşük olma durumudur.

Bu çalışmanın temel amacı disgrafi (yazma güçlüğü) yaşayan öğrenciler için etkileşimli bir yazı uygulamasının etkililiğini incelemek ve bu uygulamayı kullandıktan sonra öğrencilerin yazma becerilerinde bir gelişme olup olmadığını tespit etmektir. Araştırmada karma yöntem kullanılmıştır. Araştırmaya disgrafi yaşayan 11 öğrenci katılmıştır. Özetle çalışmanın sonuçları göstermektedir ki: 1) Yarı-deneysel uygulamadan önceki uzman görüşleri olumludur, 2) Mobil yazma uygulaması disgrafi yaşayan öğrencilerin yazma becerilerini kazanmasına (harf, hece ve kelime) katkıda bulunmuştur, 3) Her bir öğrencinin dikkatini sürdürme becerileri, yaklaşık %80 ila %100 arasında değişmektedir. Öğrencilerin yazma hızları oturum oturum incelendiğinde sürekli artış görülmektedir. Doğru girişimlerin sayısında bir artış olduğu gibi, genel olarak yanlışların sayısında azalma olmuştur. Öğrencilerin çizgi ihlali oturumdan oturuma azalma eğilimi göstermektedir. Diğer ipuçları aynı seviyede

kalırken veya artma eğilimi gösterirken, üçüncü derece ipuçlarının sunulma sayısı kademeli olarak azalmıştır, 4) Özel eğitim öğretmenlerinin yazma uygulaması hakkındaki görüşleri çok olumlu olmuştur.

Anahtar Kelimeler: Eğitim Teknolojisi, Özel Öğrenme Güçlükleri, Disgrafi, Mobil Teknolojiler, Mobil Yazma Uygulaması, El Yazısı

To my family, especially my WIFE.

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CHAPTER 1

INTRODUCTION

This chapter presents background of the study, statement of the problem, purpose of the study, significance of the study, statement of research questions, definition of terms, and organization of the study.

1.1 Background of the Study

Handwriting is one of the most important and essential skills for both literacy and beyond. Writing skills may seem simple to acquire however, writing is a complex activity that encompasses cognitive, kinesthetic, and perceptual motor component (Engel-Yeger, Nagauker-Yanuv, & Rosenblum, 2009; Reisman, 1993).

Writing is as a significant means of expressing and recording thoughts and what students have learned throughout their educational lives (Hamstra-Bletz & Blöte, 1993; Phelps, Stempel, & Speck, 1985). Instructional activities are mostly conducted based on writing on a school day. Writing is one of the basic events that students are engaged in. Writing is the most basic activity providing students to express their thoughts and feelings in the allocated time (Erhardt & Meade, 2005; Rosenblum, Weiss & Parush, 2003). In this context, it can be said that writing instruction is essential in education and it is a key factor for students' entire academic lives. Dysgraphia (impairment in writing) is defined as difficulties with written expression (APA (the American Psychological Association), 2013).

It is a fact that writing requires skills rather than knowledge and skills are acquired by practice (MONE (Ministry of National Education), 2005). Maeland and Karlsdottir (1991) express that especially in the first three years of primary school, students are expected to acquire handwriting skills sufficient enough to perform the school work. From the fourth grade or the end of elementary school, written assignments, exams, and longer written studies begin. In other words, students start writing to learn, rather

than learning to write (Reisman, 1993). From this point of view, it can be said that writing in the first three years of primary school education has a vital role. Highlighting this, a primary school student is engaged with writing activities about 30% to 60% of a school day (McHale & Cermak, 1992). It seems fair to say that students are required to acquire writing skills in terms of both form and content. However, 5% to 34% of students have difficulty in writing based on previous research. At this point, it is necessary to mention dysgraphia, which is a writing difficulty that manifests poor-quality handwriting (Hamstra-Bletz & Blöte, 1993) in school age (APA, 2013).

Dysgraphia is one of the specific learning disabilities, which is about problems with handwriting (Parastar Feizabadi, Yazdchi, Ghoshuni, & Hashemian, 2013). APA (2013) defines specific learning disabilities (disorders) as specific deficits in academic skills, which are reading, math, and writing. Dysgraphia (impairment in writing) is defined as difficulties with written expression (APA, 2013). Students with dysgraphia can have slow writing, extremely poor handwriting, illegibility of writing, spelling errors, syntax, and composition problems (Chung & Patel, 2015). As well as academic problems, cognitive ones such as difficulties in attention, memory, perceptual, metacognitive aspects, and social/emotional ones such as having lower self-esteem, less acceptance, low social status, motivational problems, difficulty stating, and understanding thoughts could appear.

Day after day, for the growing number of students with dysgraphia, educational technology is undoubtedly one of the most noteworthy educational interventions. In this context, computer based writing applications offer broad range opportunities for the benefit of students with writing disabilities (MacArthur, 2009). In addition, computer based instruction (CBI) provides cost-effective, feasible, and treatment-effective solutions (Tanimoto, Thompson, Berninger, Nagy, & Abbott, 2015). According to Zhang (2000), educational technology provides students with writing disabilities with opportunities to develop ideas and construct the sentences and paragraphs by practicing writing. Furthermore, technology makes it possible for them to express themselves and makes writing enjoyable. Another advantage of CBI is that it reduces attention problems arising from mainstream classes. Computer software, giving students with writing disabilities opportunities to practice repeatedly, play an

important role for them to become better in writing. Although there are many studies on the use of computer tools in writing disabilities (see MacArthur, 2009), few of these studies focus on how to teach writing to the students diagnosed as dysgraphia with computerized writing lesson. There exists a need to develop basic writing skills as well as new skills (MacArthur, 2009; Zhang, 2000).

Mobile devices have a great potential in education of students with writing disabilities. It is emphasized that these devices enable the students to study at their own pace (Evans, 2008; Kagohara et al. 2013) and in various places (Evans, 2008). Touch screen, mobility and design, interaction through motion, accessibility, connectivity, and ease of acquisition are main features of these devices (Fernández-López, Rodríguez-Fórtiz, Rodríguez-Almendros, & Martínez-Segura, 2013).

1.2 Statement of the Problem

Under the light of aforementioned statements in the background of the study, the first problem is that there is a gap in the literature about mobile technology usage in education of students with dysgraphia. In addition, there is a lack of empirical studies conducted in this field.

The second problem is that there is also a lack of mobile applications to meet the needs of students with dysgraphia. Literature reveals that writing requires skill rather than knowledge and skills are acquired by practice (Akyol, 2005; MONE, 2005). Therefore, insufficient number of such applications that have promising potential to provide opportunities for necessary practice is another area that needs to be addressed.

1.3 Purpose of the Study

The main purpose of the present study is to examine the effectiveness of an interactive writing application for students with dysgraphia and to determine whether there is an improvement of writing skills of the students after using this application. A writing application was developed for this purpose taking the views of subject matter experts into consideration.

1.4 The Significance of the Study

Handwriting is one of the most used skill in school and daily life. Students with dysgraphia have difficulties in writing. They are able to answer questions verbally, but find it difficult to answer in writing. Accordingly, frustration is observed among these students (Zhang, 2000) and the struggles in writing bring about emotional and social problems. According to Cahill (2009), instead of requesting help or explaining the difficulties, avoidance tendency in writing tasks shows up, and failure begins. In addition, a primary school student is engaged with writing activities about 30% to 60% of a school day (McHale & Cermak, 1992). This demonstrates the need for further research on writing difficulties. In this sense, it is considered that the present study will contribute to both educational technology and special education literature.

Writing should be considered in two stages as acquisition and development. Acquisition is about learning and using the basic knowledge. More broadly, it is concerned with teaching what the letters, syllables, words, and sentences are and how to use them in writing. Especially in early grades, writing skills should be given in accordance with rules and figures (Akyol, 2005). In line with this, if there is a problem in acquisition stage, it will be challenging to focus on the content. This is the first main reason affecting academic achievement in the writing difficulties. The second one is that teachers tend to give higher grades for legible handwriting (Graham, Harris, & Fink, 2000). Similarly, in Turkey, the need for legible handwriting skills is emphasized in Ministry of National Education curriculums (MONE 1968; MONE, 1981; MONE, 1997; MONE, 2005; MONE, 2015).

Galanis (2008) states that failures in acquisition stage can make far-going undesirable effects on academic success and self-esteem of students. Considering this, as in the early grades, the knowledge and writing performance of students with writing difficulty can be improved with the use of effective instructional strategies (Harris, Graham, & Mason, 2006). In this context, it is thought that the mobile writing applications that are developed according to the instructional design principles contribute to acquiring writing skills for both field of practice and literature.

1.5 Research Questions

This study focuses on the following research questions:

Research Question 1: What are the views of subject matter experts about mobile writing application before the utilization of the mobile writing application?

Research Question 2: Does mobile writing application contribute to acquisition of writing skills (being able to write letters, numbers, syllables, and words) for students with dysgraphia?

> *Research Question 2.1:* What are on-task behavior, writing speed, correct and incorrect attempts, line violation, and clues used of students with dysgraphia while using mobile writing application?

Research Question 3: What are the views of special education teachers about mobile writing application after the utilization of mobile writing application?

1.6 Definition of Terms

Specific Learning Disability (SLD): The diagnostic and statistical manual of mental disorders (DSM-V) defines specific learning disabilities (disorders) as specific deficits in academic skills, which are reading, math, and writing. It is manifested in school years (APA, 2013).

Dysgraphia: Dysgraphia (impairment in writing) is defined as difficulties with written expression (APA, 2013).

On-task Behavior: It was defined as: a) not talking, b) sitting during the session, c) eyes on tablet, d) focus on tablet continuously, and e) following the instructions of tablet.

Line Violation: Students should follow the line and not overflow the line 5 pixels. Even if they write the learning object [letter, syllabi or word] correctly, the answer is not accepted.

1.7 Organization of the Study

Chapter 1 reveals background of the study, statement of the problem, purpose of the study, significance of the study, statement of the research questions and definitions of terms. Chapter 2 presents the review of the related literature. Chapter 3 presents the methodology section of the study. Chapter 4 reveals the findings of the study. Chapter 5 presents discussion of the results, conclusion, suggestions, and limitations.

CHAPTER 2

LITERATURE REVIEW

2.1 Handwriting

Writing is a complex activity that encompasses cognitive, kinesthetic, and perceptual motor components (Engel-Yeger et al., 2009; Reisman, 1993). Akyol (2005) defines writing as a process of producing required symbols and signs through using motoric skills in order to express thoughts. Writing is as a significant means of expressing and recording thoughts and what students have learned throughout their educational lives (Hamstra-Bletz & Blöte, 1993; Phelps et al., 1985). The inevitability of handwriting applies to both school and beyond (Chicu, Ţicău & Şoitu, 2014).

Instructional activities are mostly conducted based on writing in a school day. Writing is the one of basic events. Writing is the most basic activity providing the students to express their thoughts and feelings in the allocated time (Erhardt & Meade, 2005; Rosenblum et al., 2003). In this context, it can be said that writing instruction is essential in education and it is a key factor for a student's whole academic lives.

As a matter of fact that writing requires skill rather than knowledge and skills are acquired by practice (MONE, 2005). Akyol (2005) states that writing instruction can be presented in different types of handwriting as manuscript, cursive, mixed-mostly manuscript, and mixed-mostly cursive (Graham, Weintraub, & Berninger, 1998), and should be considered in two stages as acquisition and development. Acquisition is about learning and using the basic knowledge of writing. More broadly, it is concerned with teaching what the letters, syllables, words, and sentences are and how to write them. Especially in early grades, writing skills should be given in accordance with rules and figures. In a similar way, Maeland and Karlsdottir (1991) express that especially in the first three years of primary school, students are expected to acquire handwriting skills sufficiently as a means to perform the school works. From fourth grade or end of the elementary school, written assignments, exams, and longer written

studies begins. In other words, students start writing to learn, not learning to write (Reisman, 1993). From this point of view, it can be said that writing in the first three years of primary school education has a vital role. Highlighting this, a primary school student engages with writing activities about 30% to 60% of a school day (McHale & Cermak, 1992). It seems fair to say that students need to acquire writing skills in terms of both form and content. However, some students may have difficulty in writing. At this point, it is necessary to mention dysgraphia.

2.2 Definition of the Dysgraphia

Dysgraphia is a writing disability which comes from Greek; dys means "impaired" and graphia means "writing letter by hand" (Chung & Patel, 2015). It is a writing difficulty, which manifests poor-quality handwriting (Hamstra-Bletz & Blöte, 1993). Dysgraphia (impairment in writing) is defined as difficulties with written expression (APA, 2013). Students with dysgraphia can have slow writing, extremely poor handwriting, illegible writing, spelling errors, syntax, and composition problems (Chung & Patel, 2015). Dysgraphia is one of the specific learning disabilities which are about problems related to handwriting (Parastar Feizabadi et al., 2013).

Korkmazlar (2003) defines an individual with SLD as someone without primer psychic illness, apparent brain pathology, and sensory disabilities, who has normal or above-normal level of intelligence (IQ > 85), but suffer from difficulties in writing, reading, arithmetic, listening, and reasoning. Additionally, the individual with SLD, who performs below the age and intelligence level despite standard education, has secondarily problems in self-management, social perception, and interaction. Because SLD affected learners who have normal or above-normal IQ scores (greater than 70), APA (2013) used unexpected academic under-achievement phase.

The diagnostic and statistical manual of mental disorders (DSM-V) defines specific learning disabilities (disorders) that are specific deficits in academic skills -reading, math, and writing- (APA, 2013).

Specific learning disabilities affect academic achievement as well as daily performance including occupational life which requires writing skills. Writing disability commonly manifests itself at school ages (APA, 2013).

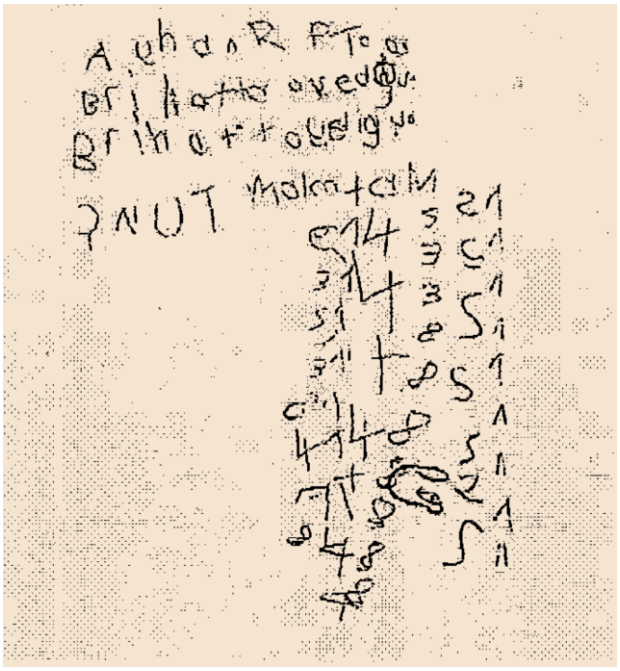

Figure 1. An example handwriting of a student with dysgraphia

2.3 Prevalence

Scholarship focusing on primary school students' writing disabilities revealed the following results with regards to the mentioned disability: 10% (Maeland, 1992), 12% (Rubin & Henderson, 1982), 5% (Hamstra-Bletz & Blöte, 1993), 22% (Smits-Engelsman, Van Galen, & Michels, 1995), 34% (Smits-Engelsman, Niemeijer, & Van Galen, 2001), and 13% (Karlsdottir & Stefansson, 2002). Alston (1985) also stated that 21% of secondary school students have writing disabilities. Studies on writing disabilities appeared extend on a spectrum that ranged between 5% and 34%.

2.4 Characteristics

Students with specific learning disabilities who have normal or above-normal intelligence are far from being similar. However, they exhibit some common characteristics. Academic, cognitive, social, and emotional characteristics will be mentioned under this title. Characteristics of students with disabilities differentiate in academic aspects; writing, reading, and arithmetic; respectively dysgraphia, dyslexia,

and dyscalculia but other aspects are common for all dyslexia, dysgraphia, and dyscalculia.

2.4.1 Academic characteristics

Students with dysgraphia have common characteristics: Illegibility in handwriting (Alberta Learning and Teaching Branch, 2002; Chung & Patel, 2015; Richards, 1998), switching to cursive and print handwriting, spending too much time thinking on which words to write, and problems with sentence completion (Chung & Patel, 2015; Richards, 1998), confusing uppercase letters with lowercase ones and writing them alternately, errors in writing letter, uncompleted (cursive) letters, irregular letter size, and shape (Reid, Elbeheri, & Everatt, 2015; Richards, 1998). Furthermore, they have tight pencil grip (Alberta Learning and Teaching Branch, 2002; Richards, 1998), problems with body position, organization problems, slow writing (speed problems), and copying (Alberta Learning and Teaching Branch, 2002; Richards, 1998) getting distracted during writing, inability to adjust letter size, lines, and margins (Richards, 1998), spelling, grammatical, and punctuation errors (Yiğiter, 2005), poor performance in written assignments and exams, and reluctance in writing (Alberta Learning and Teaching Branch, 2002).

In brief, the academic characteristics most exhibited by students are difficulties in writing. Formal and spelling mistakes are common points mentioned in the related literature. In addition to their difficulties in basic writing activities, similar difficulties exist in advanced writing activities.

2.4.2 Cognitive characteristics

Students with SLD have attention problems. Much effort has been exerted to gather attention to important stimuli in the environment (Friend, 2005; McNamara, 2007). Perceptual problems might be skipping the letter or the word despite excellent seeing while reading or misunderstanding the words despite excellent hearing while listening. In addition, there are some difficulties in short term or long-term memory or in both (Friend, 2005; McNamara, 2007). Difficulties that the students encounter are in thinking of strengths, needs and learning process and in selecting and applying new

strategies as metacognitive skills (Alberta Learning and Teaching Branch, 2002; Friend, 2005).

In brief, students with SLD also have various difficulties in the cognitive domain. Attention and perception problems are frequently mentioned in related literature for these students. Besides, the deficiencies both in metacognitive and memory development are another common point for them.

2.4.3 Social/Emotional characteristic

Students with SLD may have deficits in social skills; such as having lower self-esteem (Alberta Learning and Teaching Branch, 2002; Friend, 2005; Rowe, 2006; Zhang, 2000) and lack of recognition by friends (Alberta Learning and Teaching Branch, 2002; Friend, 2005). Because of their academic struggles or social incompetence, students with SLD may have low social status among their friends and motivational problems (Friend, 2005). Difficulty in making statement, understanding thoughts and jokes, participating in discussions, and lower level language skills may also be seen (Alberta Learning and Teaching Branch, 2002).

In brief, students with SLD experience difficulties and problems not only in the academic and cognitive domains but also in the social environment. One of the main problems addressed in literature in social context that they experience due to academic failure can cause them to have less friends and be left alone.

2.5 Technological Solutions

Educational technology is a promising solution to meet students with special needs. Under this title, computer-based instruction and mobile devices-based instruction are mentioned.

2.5.1 Computer-based instruction

Computer based applications for writing offer broad range opportunities for the students with writing disabilities (MacArthur, 2009). In addition, CBI provides cost-effective, feasible and treatment-effective solutions (Tanimoto et al., 2015). According to Zhang (2000), educational technology helps students with writing disabilities to

develop ideas and to construct sentences and paragraphs by practicing writing. Moreover, technology makes it possible for them to express themselves and thus writing becomes more enjoyable. Another advantage of CBI is that it reduces attention problems arising from mainstream classes. Computer software, which provides students with opportunities to practice writing repeatedly, plays an important role in improving their writing skills.

Although there is research on the use of computer tools in writing disabilities (see MacArthur, 2009), few of these studies focus on how to teach writing to the students diagnosed as dysgraphia with computerized writing lessons. There exists a need to develop basic writing skills as well as new skills (MacArthur, 2009; Zhang, 2000). In parallel with this, these computer tools such as word processing, word prediction, and speech recognition etc. cannot meet the need for teaching to and developing handwriting abilities of students (Giordano & Maiorana, 2014). However, today's technology offers different options from the word processor (Zhang, 2000). CBI tools such as interactive educational software, which is designed to improve fine motor skills, hand-eye coordination, and thus improving writing skills are needed (Giordano & Maiorana, 2014). Researchers must recognize the problems and difficulties of students with writing disabilities for understanding of how CBI helps students to mastering basic writing skills (Zhang, 2000).

Smits-Engelsman and Van Galen (1997) conducted a longitudinal study with 16 primary school students with dysgraphia. They revealed that the writing speed of children was increased. They used a computer software with a digitizer tablet and a special pen with a pressure-sensing device. They explored that the incorrect attempts of children were decreased while they were writing.

Rosenblum, Dvorkin, and Weiss (2006) examined the handwriting processes of the third grade students with and without dysgraphia. A computerized evaluation tool was developed in this study. An experiment with the participants of 14 dysgraphic and 14 proficient students was designed. They observed significant differences between handwritings of these two groups in terms of characteristics of their handwriting. Students with dysgraphia can be diagnosed by the educators owing to computerized evaluation tools.

Falk, Tam, Schellnus, and Chau (2011) designed a computer based handwriting assessment tool to diagnose student with writing disabilities in terms of their writing styles of incorrect space, size as well as text alignment and legibility. Out of 35 participants 1st and 2nd graders, nine of them were identified with handwriting difficulties.

Tanimoto et al. (2015) investigated the effectiveness of computerized and mobile devices based writing and reading instruction for between 4th and 9th grade students with specific learning disabilities (dyslexia, dysgraphia, and dyscalculia). They conducted a quasi-experimental study. A computerized training (visual motion cue and writing activities on a blank monitor screen) was administered to group A which consisted of 21 students. In addition, an iPad training (sequential, number, arrow cues, and writing activities between lines on iPad) was given to group B which consisted of 11 students. Training which consisted of 18 sessions was continued for 3 months. The findings of the research indicated that group B was significantly more successful than group A.

Guinet and Kandel (2010) developed a software to understand the handwriting process of both children and adults which was suitable to investigate writing disabilities. Online information was provided by the Ductus software. Ductus was designed to present velocity, duration, pauses, and fluency as different aspects of handwriting, which worked on Windows with Wacom tablet. According to the results, Ductus can facilitate studies about handwriting production.

Azimi and Mousavipour (2014) aimed to investigate effectiveness of an educational multimedia in dictation for second grade students with dysgraphia. Quasi-experimental design was utilized in the study and the control group got traditional educational procedure while experimental group used multimedia dictation. Based on the results of the study, a significant difference was found in favor of the experimental group who had educational multimedia dictation.

Chang and Yu (2014) conducted a pretest posttest design to investigate whether there was a difference among computer-assisted group, sensory motor training group and a control group. The participants of study 42 students who were 7-9 years old. The study

revealed that there was a significant difference among computer-assisted group, sensory motor training group, and a control group. Computer-assisted group showed a promising improvement in writing speed and also fluency.

Salih, Abdul-Kahar, Zahari, Khalid, and Rahim (2015) developed a 3D online game for 5 to 12 year-old students with writing and reading disabilities to teach them letters and words. Analysis was conducted after observing games that students played via mobile application. Results showed that games were in great demand for 5 to 12 year-old students.

Fedora (2015) conducted an exploratory study to investigate experiences of special and primary education teacher candidates about integration dictation software into course and to seek their future use of technology for students with writing disabilities. 13 pre-service teachers who took a course related to learning disabilities participated in the study. A survey was administered to seek opinions of teacher candidates about the integration of dictation software into course and the future use of it. The study revealed that teacher candidates had positive attitude towards technology and it is expected that they will use it in their future classrooms.

Hennion, Gentaz, Gouagout, and Bara (2005) developed a visio-haptic interface (telemaque) to teach how to write students with dysgraphia. This interface has a static aspect, which is concerned with the correct shape of letters etc. and a dynamic aspect, which is concerned with the correct order while writing the letters etc. Four practices presented by the device are as follows: 1) teaching the shape of the letter, 2) teaching correct order while writing the letter 3) teaching retrace the letter 4) teaching writing on a blank space by the visio-haptic interface. The telemaque interface was used by only one student with dysgraphia. The authors reported that further studies would be conducted with dysgraphic students by using the telemaque interface. Firstly, the telemaque was applied to 42 kindergarten students who were five year-olds. The study investigated the effectiveness of telemaque on handwriting fluency of kindergarten students before transition to formal writing instruction. It was an experimental study. Experimental group used telemaque interface and control group used classic methods. Findings of the study showed that there was a significant difference between the two groups. A significant difference was found in favor of the experimental group.

However, the authors concluded that this interface should be used for students with dysgraphia to enable improving their handwriting skills (Palluel-Germain et al., 2007).

2.5.2 Mobile devices-based instruction

Mobile devices have a great potential in education of students with writing disabilities. It is emphasized that these devices enable the students to study at their own pace (Evans, 2008; Kagohara et al., 2013) and in various places (Evans, 2008).

Main features of mobile devices stated by Fernández-López et al. (2013) are summarized below:

- Touch Screen: There is no need to learn the use of an extra tool such as mouse, keyboard etc. It can be easily used by fingers or stylus pen.
- Mobility and design: The dimensions are small, lightweight, and thus portable. Still, resolution and screen size are adequate to see the objects and symbols clearly. These devices are available everywhere all the times and their batteries last long enough to use at least for one day.
- Interaction through motion: Devices give response to rotating and shaking. This feature allows for increasing the type of interaction.
- Accessibility: Brightness of mobile devices can be adjusted to light and dark environments. Zoom feature in mobile devices enables better visibility of small objects and the symbols easily.
- Connectivity: Through Bluetooth, Wi-Fi and USB as connection types, these devices can communicate with other devices and connect to the Internet.
- Ease of acquisition: It is easy to get these devices, to find and download applications. Thus, devices can help to find and this increases the use of instructional material by teachers, students and parents.

Diah, Ismail, Hamid, and Ahmad (2012) carried out a study with children between the ages of four and six who have writing difficulties. Computer assisted software (AJaW) was developed based on Hannafin's and Peck's Instructional models to demonstrate how to grip pencil, pre-writing activity, practices, and evaluation for motor-skills development by using graphic tablet. AJaW was tested in terms of appearance,

learnability and scaffolding. Results revealed that students found AJaW enjoyable and they were able to improve motor skills. The software has been developed for helping students in complex skills about writing.

Giordano and Maiorana (2014) developed a web-based, platform-free, and usable with tablets and smartphones educational software, which was based on gesture recognition algorithm, for students with dysgraphia. Different exercise types (connecting dots, and writing a given word again a blank space, etc.) and feedback were presented by the software. Also the data taken from users were recorded and enabled real time statistics for individualized learning. The software has been continued to test effectiveness and other aspects on dysgraphic students.

Czyzewski, Odya, Grabkowska, Grabkowski, and Kostek (2009) developed a smart pen, which consisted of hardware and software parts to improve writing skills of students with dysgraphia. The smart pen system provided opportunity for students to make practice with teacher/therapist. Results were indicated that teacher and students were interested in using the system.

In Turkish literature, there is some research on different aspects of writing disabilities (Akyol & Yıldız, 2010; Ates, Cetinkaya, & Yildirim, 2014; Ateş, Yıldırım, & Yıldız, 2010; Yıldız, 2013). Yet, studies about educational technology used in writing disabilities (dysgraphia) are very limited (Yılmaz, 2014).

Yılmaz (2014) developed mobile software based on android devices, which used Tesseract handwriting recognition algorithm. It was suggested that the mobile software could be used for students with writing disabilities in education. Educators can create their educational sets.

2.6 Implications of Literature Review

Handwriting is one of the most used skill in school and daily life. Students with dysgraphia have difficulties in writing. They are able to answer questions verbally, but find it difficult to answer in writing. Accordingly, frustration is observed among these students (Zhang, 2000) and the struggles in writing bring about emotional and social problems. According to Cahill (2009), instead of requesting help or explaining the

difficulties, an avoidance tendency in writing tasks shows up, and failure begins. In addition, a primary school student is engaged with writing activities about 30% to 60% of a school day (McHale & Cermak, 1992). Mobile devices have a great potential in education of students with writing disabilities. It is emphasized that these devices enable the students to study their own pace (Evans, 2008; Kagohara et al., 2013) and in various places (Evans, 2008). Touch screen, mobility and design, interaction through motion, accessibility, connectivity, and ease of acquisition are main features of these devices (Fernández-López et al., 2013). Under the light of literature, there exists a gap in the literature about mobile technology usage in education of students with dysgraphia and lack of empirical studies supported in this field. In Turkish literature, there is a few research on different aspects of writing disabilities (Akyol & Yıldız, 2010; Ates et al., 2014; Ateş et al., 2010; Yıldız, 2013). Yet, studies about educational technology used in writing disabilities (dysgraphia) are very limited (Yılmaz, 2014). This demonstrates the need for further research on writing difficulties. In this sense, it is considered that present study contributes to both educational technology and special education literature.

Writing should be considered in two stages as acquisition and development. Acquisition is about learning and using the basic knowledge. More broadly, it is concerned with teaching what the letters, syllables, words, and sentence are and how to use them in writing. Especially in early grades, writing skills should be given in accordance with rules and figures (Akyol, 2005). In line with this, if there is a problem in acquisition stage, it will be challenging to focus on the content. This is the first main reason affecting academic achievement in the writing difficulties. The second one is that teachers tend to give higher grades for legible handwriting (Graham et al., 2000). In our country, it emphasized the need for legible handwriting skills in MONE curriculums (MONE 1968; MONE, 1981; MONE, 1997; MONE, 2005; MONE, 2015). Although there is many research on the use of computer tools in writing disabilities (see MacArthur, 2009), few of these studies teach writing to the students with computerized writing lessons identified as dysgraphia. There exists a need to develop basic writing skills as well as new skills (MacArthur, 2009; Zhang, 2000). In this context, there exists a lack of mobile applications to meet needs of student with

dysgraphia. Therefore, insufficient number of such applications that have promising potential to provide the opportunities of the required practice is another problem.

Galanis (2008) states that failures in acquisition stage can make far-going undesirable effects on academic success and self-esteem of students. Considering this, as in the early grades, the knowledge and writing performance of students with writing difficulty can be improved with the use of effective instructional strategies (Harris et al., 2006). However, there is scarcity of empirical evidence about the ways in which students' writing skills could be improves through effective means of mobile writing applications. In this context, this unique study focuses on improving writing skills of students with dysgraphia via a mobile writing application developed by the researcher and reports findings of the experimental study. Therefore, this study is expected to bring unique insights for both the practitioners and the scholars working in the fields of primary education, special education, and educational technology. The method used in the study is based on an interdisciplinary approach to highlight the needs of students who suffer from the problems of dysgraphia and develop a mobile application that meets the needs of students involved in the learning process.

CHAPTER 3

METHODOLOGY

This chapter presents research questions, research design, participants, instruments, procedures, pilot study, development of software, data analysis of the study, experimental validity, and reliability and validity issues for qualitative part.

3.1 Research Questions

This study focuses on the following research questions:

Research Question 1: What are the views of subject matter experts about mobile writing application before the utilization of the mobile writing application?

Research Question 2: Does mobile writing application contribute to acquisition of writing skills (being able to write letters, numbers, syllables, and words) for students with dysgraphia?

> Research Question 2.1: What are on-task behavior, writing speed, correct and incorrect attempts, line violation, and clues used of students with dysgraphia while using mobile writing application?

Research Question 3: What are the views of special education teachers about mobile writing application after the utilization of mobile writing application?

The independent variables are the treatment and mobile writing application, and the dependent variable is writing skill.

3.2 Research Design

A mixed method design which includes both quantitative and qualitative means was employed in this study (see Figure 2). While the quantitative part of the study included pretest-posttest quasi experimental design (see Table 1), log data (quantitative part), and observation for on-task behavior; the qualitative part of the study used mobile writing application evaluation forms, pretreatment questionnaires, semi-structured

interviews, and log data (qualitative part). Before the treatment, a pretreatment questionnaire was used in order to obtain demographic information and diagnosis of students. A pretest was administered to students before the treatment; in a similar manner, a posttest was administered to students after the treatment. Treatment was continued until students studied all content of application. The qualitative part of the study included mobile writing application evaluation form with open-ended questions revealing ideas of special education experts, educational technology experts, classroom education experts and a classroom teacher before the experiment. A semi-structured interview protocol was conducted after the experiment with special education teachers for in-depth analysis. In addition, there were collected data from mobile writing application log. Quantitative part of the log was kept the number of correct uppercase and lowercase letter, incorrect uppercase and lowercase letter, correct syllabi, incorrect syllabi, correct word, incorrect word, percentage of correct writing, and time. Qualitative part of the log was kept written items, clues used, and violated lines. An observation protocol was used in order to determine students' on-task behavior. Both quantitative and qualitative data supported each other and this increased reliability.

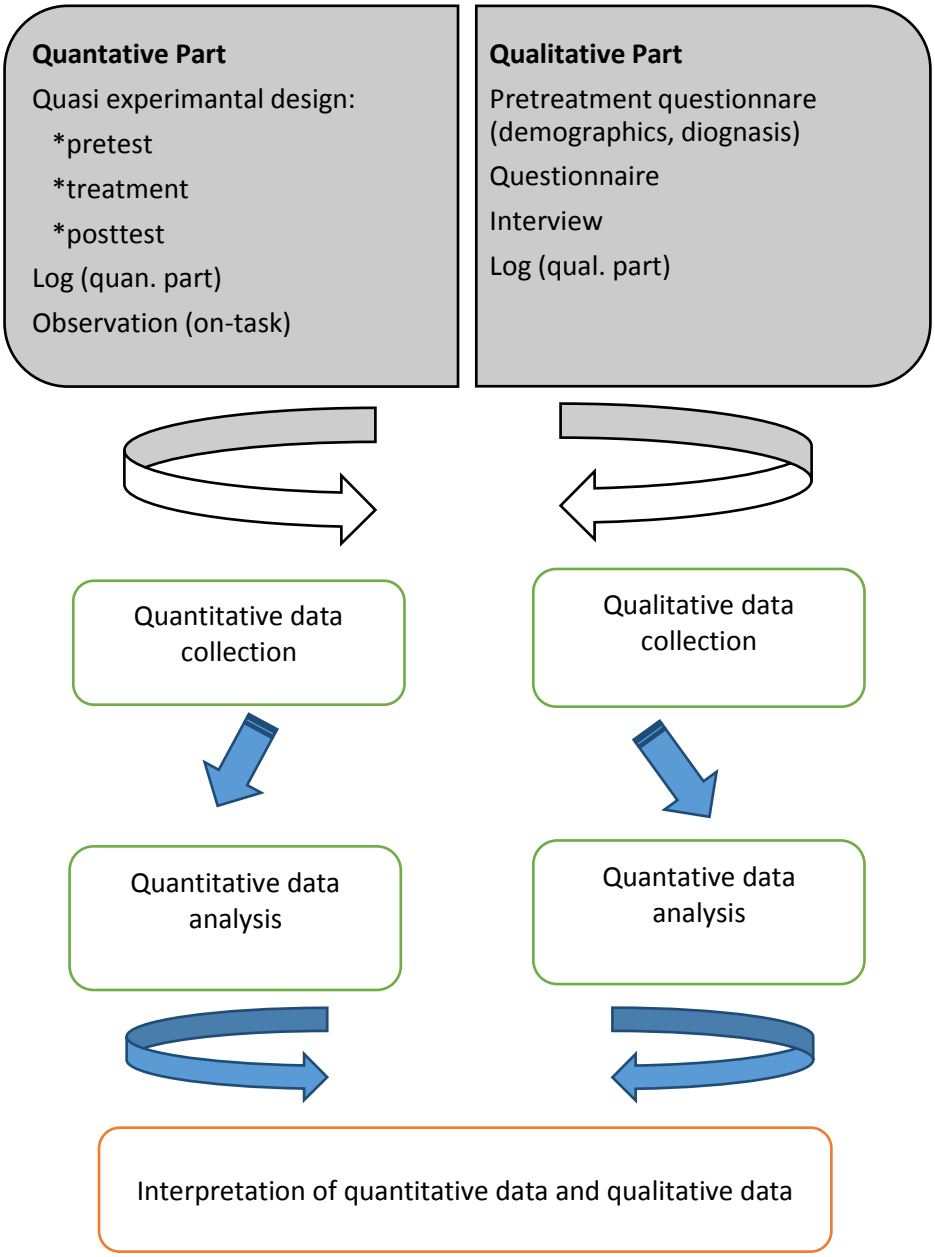

Figure 2. Research design of the study

Table 1. Quantitative part of the study

Groups	Before Treatment	Treatment	After Treatment
Students with dysgraphia (n=11)	Pretest	Mobile Writing Application	Posttest

Table 2. Participants, phases, instrument and data analysis techniques of the study

Participant(s)	Phase	Instrument	Data Analysis
Special education experts (n=4) Educational technology experts (n=5) Classroom education experts/teacher (n=4)	Before the treatment	Mobile writing application evaluation form	Descriptive statistic
Students (n=11)	Throughout during the treatment	Mobile writing application, The Log, Observation Form for On-task Behavior	Wilcoxon signed ranks test Graphical analysis
Special education teachers (n=7)	After the treatment	Semi-structured interview protocol	Descriptive analysis

3.3 Participants

In quantitative phase, purposeful sample procedure was employed due to the fact that target group of this study was students with dysgraphia. Three students with dysgraphia who were in 3rd grades participated to pilot study (see Table 11), while 11 students with dysgraphia attending 1st-8th grades in primary schools participated to experiment. Student selection process in the experimental phase is explained below.

Firstly, a list of special education and rehabilitation centers in Istanbul which implement specific learning disabilities program has requested from the Ministry of Education. After a couple of visits to special education center in Gaziosmanpaşa and Eyüp districts of Istanbul during 2015-2016 spring semester, YI Special Education and

Rehabilitation Center which had 380 students and YCD Special Education and Rehabilitation Center which had 250 students were selected because of the amount of the students. After, a seminar introducing the study to teachers and administrators, 51 students were observed by the researcher. The schedules of these students were asked and absentees were determined. 40 students were eliminated due to the following reasons (see Table 3):

1) 25 students were eliminated due to absenteeism.
2) 2 students were eliminated because the additional diagnosis of hyperactivity.
3) 8 students were eliminated because there was no need to writing programs.
4) 2 students were eliminated for being left-handed.
5) 1 student was eliminated because of behavior and speech disorders.
6) 2 students were eliminated because of being not sufficient to use the application.

In the study, code names were given to students and special education centers.

Table 3. Student selection process

Code	Age	Reason of Elimination
YT	6	no need
IG	7	no need
NK	7	no need
FNV	10	no need
BK	11	no need
NV	11	no need
OU	11	no need
SCK	11	no need
IO	7	absenteeism
AEK	8	absenteeism
EK	8	absenteeism
OAO	8	absenteeism
SK	8	absenteeism
UHA	8	absenteeism
YG	8	absenteeism
DD	8	absenteeism
EK	9	absenteeism
TTB	9	absenteeism
TS	9	absenteeism
AS	10	absenteeism
YF	10	absenteeism

Table 3. (continued)

YE	10	absenteeism
AC	11	absenteeism
KK	11	absenteeism
UG	11	absenteeism
AA	12	absenteeism
EY	12	absenteeism
OCB	14	absenteeism
DS	9	absenteeism
RR	9	absenteeism
EES	8	absenteeism
ET	7	absenteeism
HT	7	absenteeism
AG	7	hyperactivity
EO	8	hyperactivity
TK	9	Left-handed
CEC	9	Left-handed
AE	7	Behavior and speech disorders
ES	7	Not sufficient to use the application
KY	8	Not sufficient to use the application

As a result of selection process, 11 students were included to study. Demographic information and information of participants were presented in Table 4 and Table 5 respectively.

RS was an 8 years old female who had specific learning disabilities (dysgraphia) with a 20% of disability rate. She was attending 3rd grade in a public school and also special education and rehabilitation center for one year twice a week. She was diagnosed by hospital on 09/16/2015. Her on-task behavior time was approximately 25 min. She did not have a tablet at home. She never used tablet, and stylus pen.

HE was a 9 years old female who had specific learning disabilities (dysgraphia) with a 20% of disability rate. She was attending 5th grade in a public school and rehabilitation center for one year twice a week. She was diagnosed by hospital on 03/25/2015. She also took educational help from her teacher. Her on-task behavior time was approximately 45 min. She had a tablet which she used for entertainment. She never used a stylus pen.

AT was an 8 years old female who had specific learning disabilities (dysgraphia) with a 20% of disability rate. She was attending 3rd grade in a public school and also special education and rehabilitation center for one year twice a week. She was diagnosed by hospital on 02/09/2015. Her on-task behavior time was approximately 10 min. Although she did not have a tablet at home, she had the experience of using tablet for entertainment. She never used a stylus pen.

DT was a 10 years old female who had specific learning disabilities (dysgraphia) with a 20% of disability rate. She was attending 4th grade in a public school and also special education and rehabilitation center for one year twice a week. She was diagnosed by hospital on 04/13/2016. Her on-task behavior time was approximately 45 min. Although she did not have a tablet at home, she had the experience of using tablet for entertainment. She never used a stylus pen.

GS was a 10 years old male who had specific learning disabilities (dysgraphia) with a 30% of disability rate. He was attending 5th grade in a public school and also special education and rehabilitation center for one year twice a week. He was diagnosed by hospital on 03/11/2015. He also took educational help from his mother. His on-task behavior time was approximately 20 min. He had a tablet which he used for entertainment. He never used a stylus pen.

MAU was a 10 years old male who had specific learning disabilities (dysgraphia) with a 30% of disability rate. He was attending 5th grade in a public school and also special education and rehabilitation center for three years twice a week. He was diagnosed by hospital on 12/02/2013. His on-task behavior time was approximately 35 min. Although he did not have a tablet at home, he had the experience of using tablet for entertainment. He never used a stylus pen.

BY was a 9 years old female who had specific learning disabilities (dysgraphia) with a 20% of disability rate. She was attending 4th grade in a public school and also special education and rehabilitation center for one year twice a week. She was diagnosed by hospital on 09/25/2015. She also took educational help from her mother and sister. Her on-task behavior time was approximately 15 min. She had a tablet which she used for entertainment. She never used a stylus pen.

SC was a 10 years old female who had specific learning disabilities (dysgraphia) with a 20% of disability rate. She was attending 5th grade in a public school and also special education and rehabilitation center for one year twice a week. She was diagnosed by hospital on 03/18/2015. She also took educational help from her parents and grandparents. Her on-task behavior time was approximately 45 min. She had a tablet which she used for entertainment. She never used a stylus pen.

MAC was a 10 years old male who had specific learning disabilities (dysgraphia) with a 36% of disability rate. He was attending 5th grade in a public school and also special education and rehabilitation center for three years twice a week. He was diagnosed by hospital on 08/14/2012. His on-task behavior time was approximately 7 min. He had a tablet which he used for entertainment. He never used a stylus pen.

MYP was an 11 years old male who had specific learning disabilities (dysgraphia) with a 25% of disability rate. He was attending 6th grade in a public school and also special education and rehabilitation center for one year twice a week. He was diagnosed by hospital on 09/17/2005. His on-task behavior time was approximately 35 min. He had a tablet which he used for entertainment. He never used a stylus pen.

KH was a 10 years old male who had specific learning disabilities (dysgraphia) with a 20% of disability rate. He was attending 5th grade in a public school and also special education and rehabilitation center for three years twice a week. He was diagnosed by hospital on 08/02/2013. He also took educational help from his mother and a pedagogue. His on-task behavior time was approximately 5 min. He did not have a tablet at home. He never used tablet and stylus pen.

Table 4. Demographic information about students

Code	Gender	Age	Grade	Type of Disability	Disability Rate (%)	Diagnosed by Institution	Date of diagnosis
RS	Female	8	3	SLD (Dysgraphia)	20	Hospital	09/16/2015
HE	Female	9	5	SLD (Dysgraphia)	20	Hospital	03/25/2015
AT	Female	8	3	SLD (Dysgraphia)	20	Hospital	02/09/2015
DT	Female	10	4	SLD (Dysgraphia)	20	Hospital	04/13/2016
GS	Male	10	5	SLD (Dysgraphia)	30	Hospital	03/11/2015
MAU	Male	10	5	SLD (Dysgraphia)	30	Hospital	12/02/2013
BY	Female	9	4	SLD (Dysgraphia)	20	Hospital	09/25/2015
SC	Female	10	5	SLD (Dysgraphia)	20	Hospital	03/18/2015
MAC	Male	10	5	SLD (Dysgraphia)	36	Hospital	08/14/2012
MYP	Male	11	6	SLD (Dysgraphia)	25	Hospital	09/17/2005
KH	Male	10	5	SLD (Dysgraphia)	20	Hospital	08/02/2013

Table 5. Information about students

Code	School Type	Special Education and Rehabilitation Center Name	Attendance Year to Special Education and Rehabilitation Center	Attendance Frequency	Additional Educational Help	On-task Behavior Time (~)	Tablet at Home	Experience on Tablet Use	Purpose of Tablet Use	Experience on Stylus Pen Use
RS	Public	YI	1 Year	Twice a week/45 min.	-	25 min.	No	No	-	No
HE	Public	YI	1 Year	Twice a week/45 min.	Special Teacher	45 min.	Yes	Yes	Game	No
AT	Public	YI	1 Year	Twice a week/45 min.	-	10 min.	No	Yes	Entertainment	No
DT	Public	YI	1 Year	Twice a week/45 min.	-	45 min.	No	Yes	Entertainment	No
GS	Public	YI	1 Year	Twice a week/45 min.	Mother	20 min.	Yes	Yes	Entertainment	No
MAU	Public	YI	3 Years	Twice a week/45 min.	Mother	35 min.	No	Yes	Entertainment	No
BY	Public	YCD	1 Year	Twice a week/45 min.	Mother Sister	15 min.	Yes	Yes	Entertainment	No
SC	Public	YCD	1 Year	Twice a week/45 min.	Parents Grandparents	45 min.	Yes	Yes	Entertainment	No
MAC	Public	YCD	3 Years	Twice a week/45 min.	-	7 min.	Yes	Yes	Entertainment	No
MYP	Public	YCD	1 Years	Twice a week/45 min.	-	35 min.	Yes	Yes	Entertainment	No
KH	Public	YCD	3 Years	Twice a week/45 min.	Mother Pedagogue	5 min.	No	No	-	No

In qualitative phase, four special education experts, five educational technology experts, and four classroom education experts/ teacher participated (see Table 6, 7, and 8). Demographic information and additional information were taken from special education teachers by using pretreatment questionnaire (see Table 9). The pretest and posttest were evaluated by three classroom education experts (see Table 10). Semi-structured interviews were conducted after the experiment with seven special education teachers (see Table 9).

Table 6. Information about special education experts

Code	Degree	Gender	Experience
SP1	Ph.D.	Male	20 Years
SP2	Ph.D.	Female	20 Years
SP3	Ph.D.	Female	20 Years
SP4	Ph.D.	Female	6 Years

Table 7. Information about classroom education experts and the classroom education teacher

Code	Degree	Gender	Experience
CE1	Ph.D.	Female	13 Years
CE2	Ph.D.	Female	13 Years
CE3	MS	Female	6 Years
CT1	MS	Male	6 Years

Table 8. Information about educational technology experts

Code	Degree	Gender	Experience
ET1	Ph.D.	Male	17 Years
ET2	Ph.D.	Male	16 Years
ET3	Ph.D.	Male	4 Years
ET4	Ph.D.	Male	9 Years
ET5	Ph.D.	Female	7 Years

Table 9. Information about special education teachers

Code	Gender	Age	Experience
ST1	Female	26	2 Years
ST2	Male	70	49 Years
ST3	Male	29	8 Years
ST4	Male	60	41 Years
ST5	Male	23	6 Months
ST6	Female	24	2 Years
ST7	Female	27	5.5 Years

Table 10. Information about classroom education experts in evaluation pretest-posttest

Code	Degree	Gender	Experience
CE1	Ph.D.	Female	13 Years
CE2	Ph.D.	Female	13 Years
CE3	Ph.D. Candidate	Female	6 Years

Table 11. Information about students in pilot study

Code	Gender	Age	Session Date
S1	Male	10	13.02.2016
S2	Female	9	18.02.2016
S3	Female	9	05.03.2016

3.4 Instruments

Mobile writing application and the log: An Android version of this application was developed by using Adobe Animate for this study. It used gesture recognition algorithm to recognize handwriting of the students. Uppercase and lowercase letters, numbers, syllabi, and word were included as content. Application log kept study time, the percentage of correct writing, correct uppercase and lowercase letters, incorrect uppercase and lowercase letters, correct and incorrect numbers, correct and incorrect syllables, correct and incorrect words in the database. Detailed information about mobile writing application were presented under development of software title.

Mobile Writing Application Evaluation Form: This form, which included three sub-forms with open-ended questions were developed in order to reveal the ideas of

special education experts, educational technology experts, classroom education experts, and the classroom education teacher before the experiment. The form investigated the views of experts and the teacher in terms of perceived ease of use, perceived usefulness, perceived enjoyment, educational content, visual design, multimedia use, and technical features. Questions about the perceived ease of use, and perceived usefulness, were adapted from Davis (1989); questions about perceived enjoyment were adapted from Venkatesh and Bala (2008). The remaining questions were developed by the researcher.

The form for special education experts consisted of five questions about perceived ease of use, six questions about perceived usefulness, four questions about perceived enjoyment, five questions about educational content, one question about visual design, and four questions about multimedia use, in total 25 questions (Appendix A).

The form for classroom education experts and the classroom education teacher consisted of three questions about perceived ease of use, five questions about perceived usefulness, and seven questions about educational content, in total 15 questions (Appendix A).

The form for educational technology experts consisted of five questions about perceived ease of use, five questions about perceived usefulness, four questions about perceived enjoyment, one question about educational content, one question about visual design, four questions about multimedia use and two questions about technical features, in total 22 questions (Appendix A).

Semi-structured interview protocol: A semi-structured interview protocol was developed after the experiment to be given to the special education teachers for in-depth analysis of the application. It consisted of five questions and seven sub-questions (Appendix B).

Observation Form: An observation form was developed in order to determine students' on-task behavior while they were using the application. It consisted of eight items. When students performed one of eight items, the researcher paused the stopwatch (Appendix C).

Pretreatment questionnaire: A pretreatment questionnaire was used in order to obtain demographic information and diagnosis of students. It consisted of 19 questions (Appendix D).

Pretest-Posttest: In order to compare the writing skills of students with dysgraphia before and after using the application, a pretest-posttest which has a content starting from letter to words were integrated into the mobile writing application. The content was determined with classroom education experts. After students had completed the pretest and posttest, the screen captures were shown to three classroom education experts. They evaluated these test results in terms of the inclination (one question), size (one question), spacing (one question), line tracking (one question), and form (one question) in total five questions by using multi-dimensional legibility scale developed by Yıldız and Ateş (2010) (Appendix E).

3.5 Procedures

Pilot study was carried out for one session with three students with dysgraphia. The pilot study aimed to evaluate the mobile writing application in terms of instructional design, visual design, and usability through observation. Lowercase letter, uppercase letter, and number modules were developed for the pilot study. After piloting the study, necessary revisions were made.

Mobile writing application evaluation form with open-ended question was applied to special education experts, educational technology experts, classroom education experts, and the classroom education teacher to reveal their ideas about the application before the experiment. It took approximately 30 minutes. Some improvements were made. They were mentioned in the pilot study title.

A pretreatment questionnaire was applied to special education teachers in order to obtain demographic information and diagnosis of the students. An institutional review board (IRB) report was taken from METU Ethics Division (Appendix F). Parental consent forms were taken from the parents of selected students (Appendix G). A pretest was administered to the students before the treatment. Treatment was continued until students studied all content of application in summer term. Observations and video recordings were employed during the treatment. In addition,

the researcher collected data in log during the treatment. Similar to pretest, a posttest was administered to students after the treatment. When students completed the pretest and posttest, the screen captures were shown to three classroom education experts. It took approximately two hours. A semi-structured interview protocol was given to the special education teachers after the experiment for in-depth analysis of the application. Each interview took approximately 20 minutes.

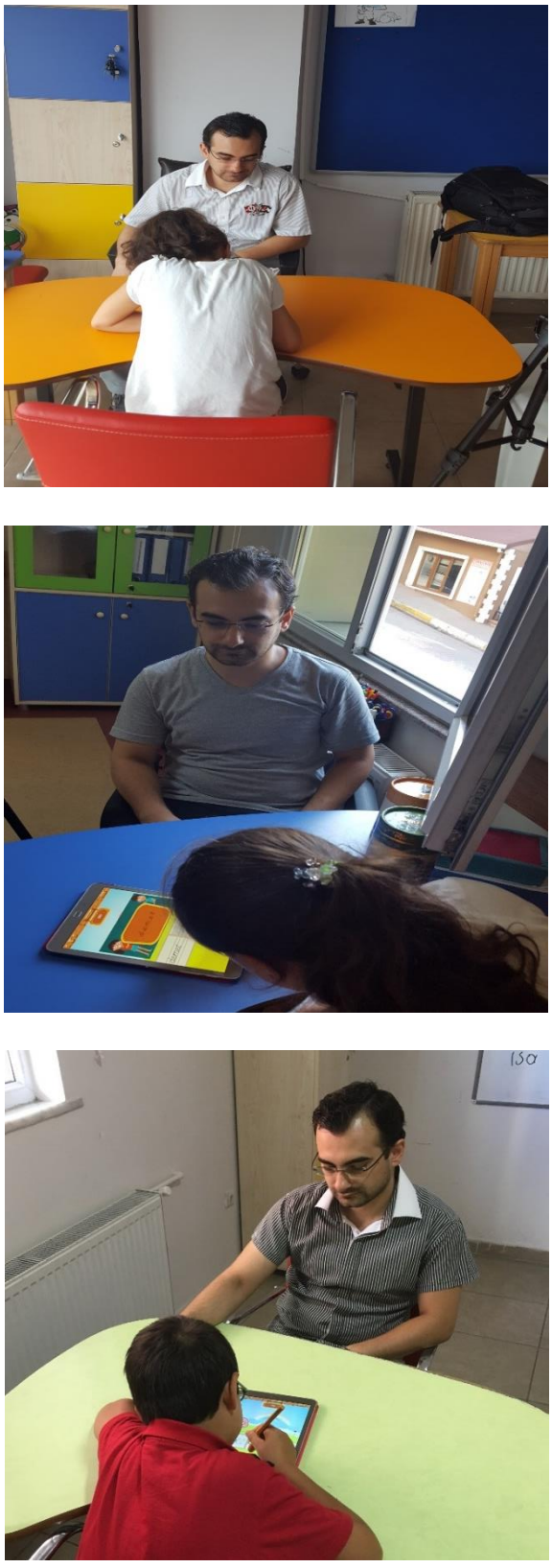

Figure 3. Sessions

3.6 Pilot Study

The pilot study was held in 2015-2016 academic year with three students with dysgraphia. Two of them were 9-year-old girls and one of them was a 10 year- old boy. The students had specific learning disabilities. They have problems in writing. The pilot study was carried out in order to evaluate the visual design, instructional design and usability through observation. It was conducted by the researcher himself and was observed by another researcher in educational technology field. Two of them did not attend any special education centers. S1 had been attending a counseling center. Three of them were studying at a state school.

At the beginning of the pilot study, the parents were informed about the study and parental consent forms were taken from them (Appendix G). An application including 29 uppercase and lowercase letters, and numbers (Figure 3) was developed for the pilot study. Observations and video camera recording were carried out during the pilot study. One session was held for each participant on different dates (Table 11). The sessions including uppercase letters, lowercase letters and numbers parts took approximately 30 minutes for both S2 and S3, and 18 minutes for S1 (Table 12).

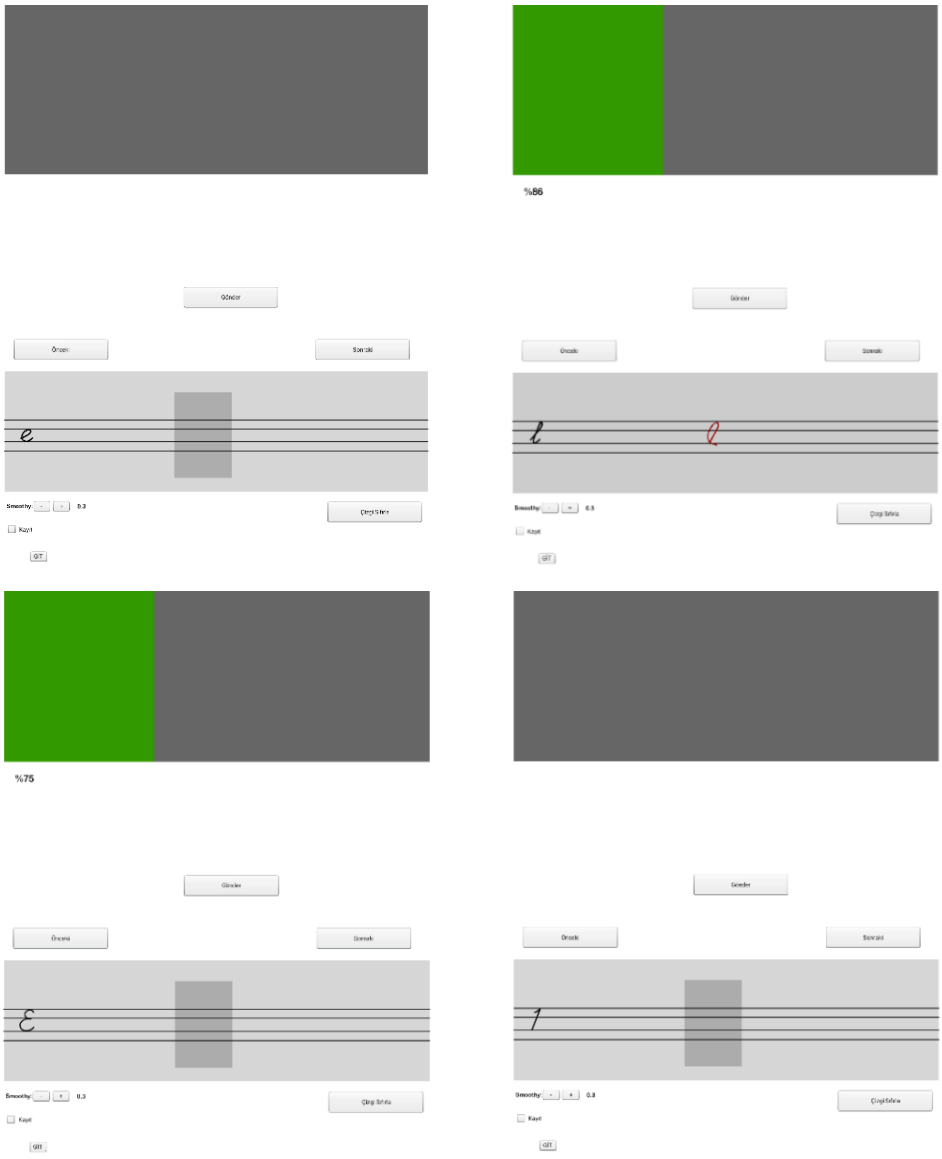

Figure 4. Screenshots from pilot application

Table 12. Completion times of students in pilot study

Sections	S1	S2	S3
Lowercase Letters	10 min.	14.5 min.	20 min.
Uppercase Letters	6 min.	17 min.	12 min.
Numbers	2 min.	5 min.	2 min.
Total	18 min.	36.5 min.	34 min.

After pilot study was completed, the results were discussed with two special education experts and one educational technology expert. Some improvements had been made on mobile writing application according to the observations from the pilot study and discussions.

S1 thought his drawing was wrong since his own drawings did not look like the letter displayed on the screen. To overcome this problem, line correction and smoothing algorithm was used in order to prevent the students' writings from looking like incorrect. In this way, smoothing lines and pixel skipping problems were resolved during writing.

Due to lack of palm rejection feature in horizontal axis and toolbar location (bottom) in Samsung Tab 2, some letters could not be written by using stylus pen by S1. For that reason, S1 wanted to write or delete the letters using his finger. Palm rejection feature in vertical axis had been adjusted before, likewise, it was decided to adjust horizontal axis also. Tablet was changed with TAB S2.

S1 got bored to write each letter three times. Therefore, he passed the letter himself by using the next button. To overcome this problem a dart game was included to application.

S2 wrote some letter by starting from the opposite direction. To overcome this problem, clues to teach writing direction of the letters were included.

Even for several letters she wrote accurately, she could not follow the line. To overcome this problem, line control should be enabled in the application.

S3 wanted to write close to sample letter on the screen yet she could not write because of writing out of the line. A distinguishing space/part should be added between the area where the student writes and the sample letter.

Similar to S2, for several letters even she wrote accurately she could not follow the line. To overcome this problem, line control should be enabled in the application.

3.7 Development of Software

An Android version of this application was developed by using Adobe Animate for this study. It used gesture recognition algorithm to recognize handwriting of students. An open gesture recognition algorithm developed by Wobbrock, Wilson, and Li (2007) was adapted in terms of need of this application. Permission was taken from the first author (Appendix H). Gesture recognition defines as pertains to recognizing meaningful expressions of motion by a human, involving the hands, arms, face, head, and/or body." (Mitra & Acharya, 2007, p.1.). In this study, it is important to recognize motion of students' hand during the writing processes.

In this application, reference points were obtained by going through letters, numbers, syllabi and words. Different reference points were determined for different targets in order to overcome overlapping reference points for different targets.

```
stop();
import de.yuv.gestures.Recognizer;
MovieClip(root)["anaekran"]["myRec"] = new Recognizer();
MovieClip(root)["anaekran"]["myRec"].addTemplate("e", new Array(
new Point(440,127),new Point(441,127),new Point(442,127),new Point(443,127),
new Point(446,127),new Point(449,126),new Point(451,125),new Point(454,124),
new Point(455,123),new Point(455,123),new Point(455,122),new Point(456,121),
new Point(456,121),new Point(457,119),new Point(458,118),new Point(458,118),
new Point(458,117),new Point(459,115),new Point(459,113),new Point(460,112),
new Point(460,110),new Point(460,109),new Point(460,108),new Point(460,108),
new Point(460,108),new Point(459,108),new Point(458,108),new Point(457,109),
new Point(456,109),new Point(454,111),new Point(450,112),new Point(446,116),
new Point(443,120),new Point(441,125),new Point(440,128),new Point(442,131),
new Point(447,132),new Point(453,132),new Point(455,132),new Point(456,132),
new Point(458,132),new Point(458,131),new Point(460,130),new Point(461,129),
new Point(461,127),new Point(462,125)));
MovieClip(root)["anaekran"]["cizgi_dogru"]=[0,0,0,0];
```

Figure 5. Determining reference points in adapting process of gesture recognition algorithm

Also, line correction and smoothing algorithm was employed in order to prevent the students' writings from looking like incorrect. In this way, smoothing lines and pixel skipping problem resolved during the writing. An open line correction and smoothing algorithm developed by Dan Gries was adapted (Gries, n.d.).

Registration screen is the first screen. After the researcher register with a user name, introduction, which gives a general instruction about the application, is shown to the students.

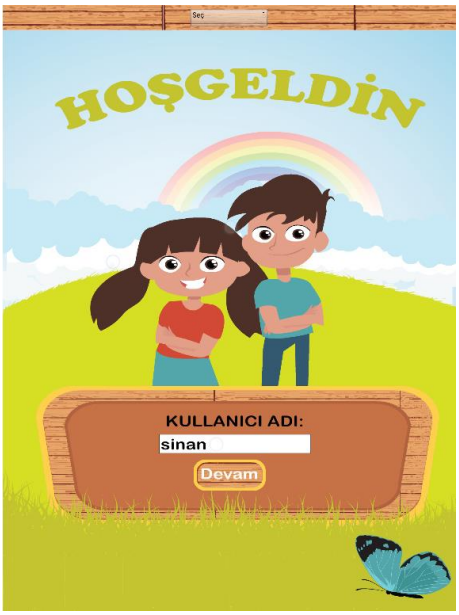

Figure 6. Registration screen

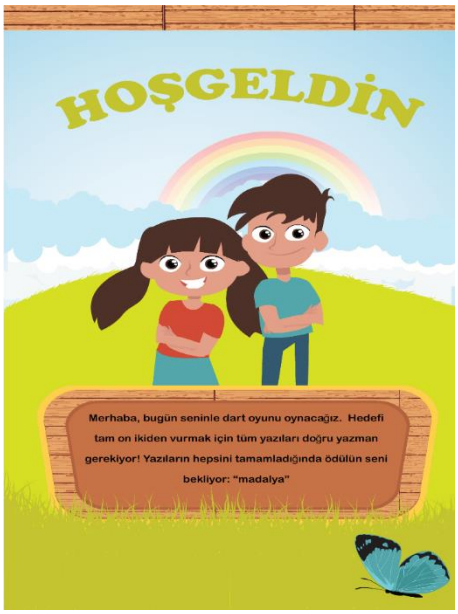

Figure 7. Introduction screen

Mobile writing application consists of the following three main parts:

3.7.1 Pretest-posttest

After registration and first introduction screens, pretest and posttest were presented to students. Pretest and posttest includes 29 lowercase letters, 29 uppercase letters, 20 syllabi and words. The content of pretest and posttest was selected from the course book (Doğan Temur, 2015), MONE (2015) curriculum considering classroom teacher's and experts' views. Pretest and posttest results of students were saved in tablet memory as jpeg files for the evaluation.

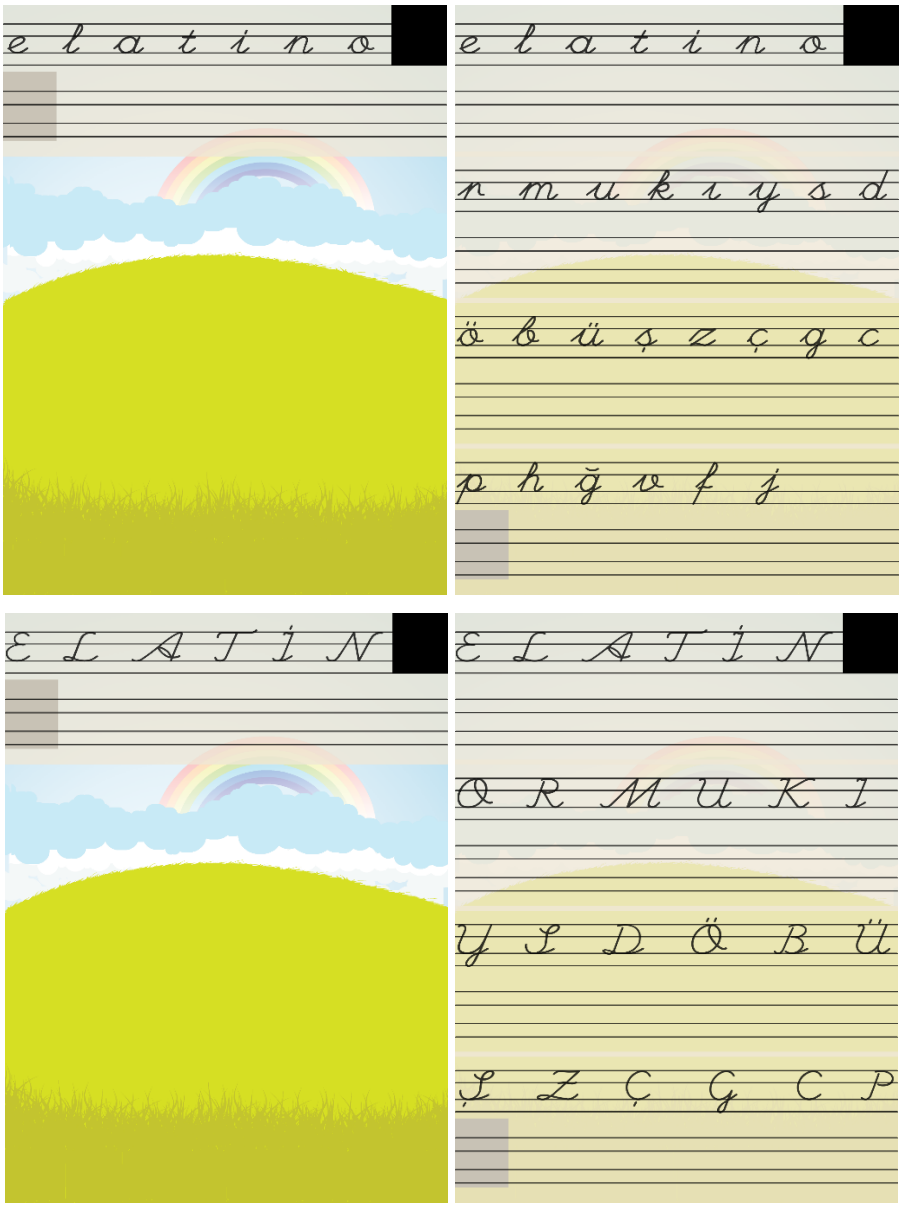

Figure 8. Screenshots from pretest-posttest

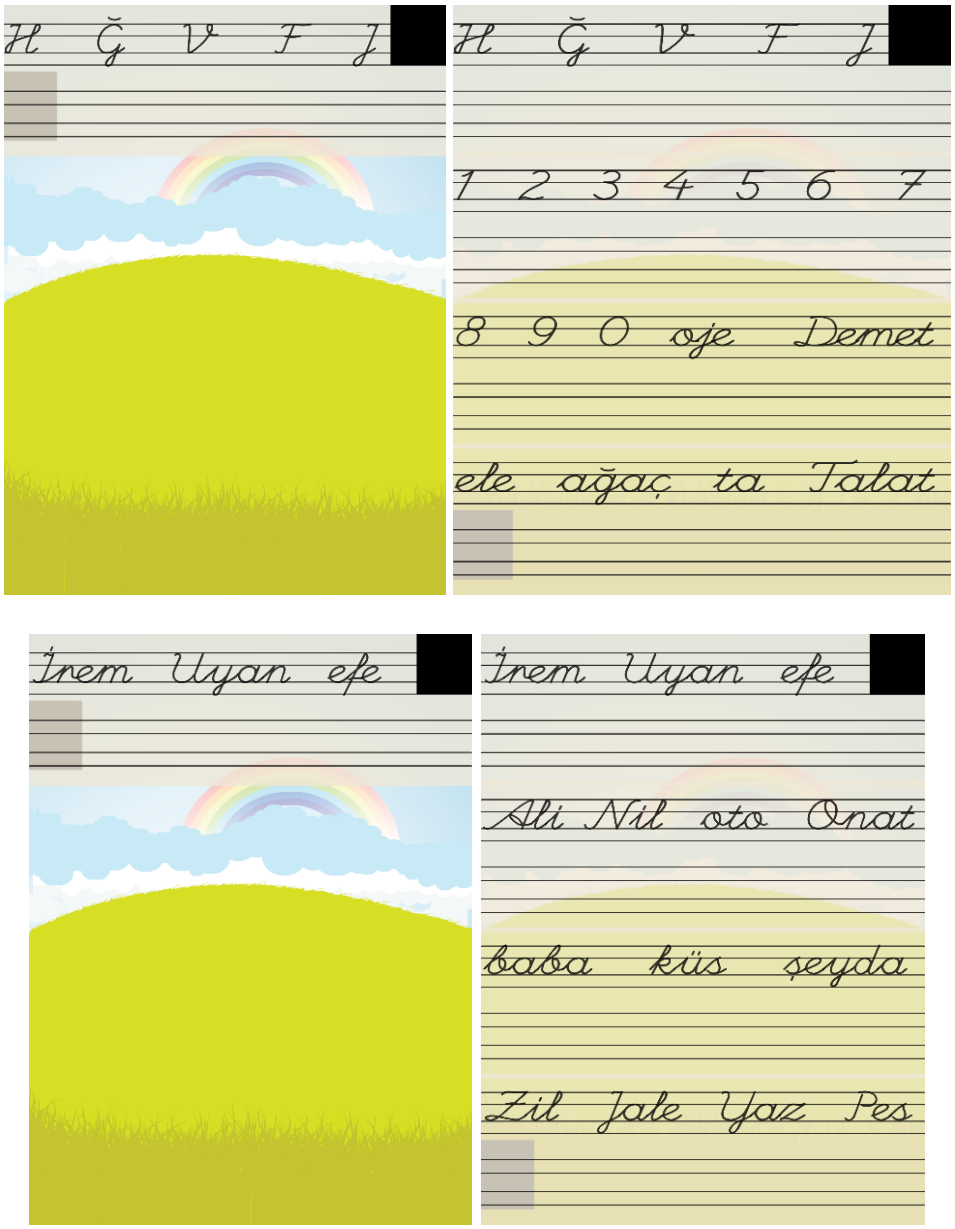

Figure 8 (continued)

3.7.2 Trial screen

A trial screen was developed to provide adequate support to start the application and get used to use the stylus pen. In this screen, there were five different lines on the trial screen and each line has an animal and the food on. If students draw the line, the animal reaches the food.

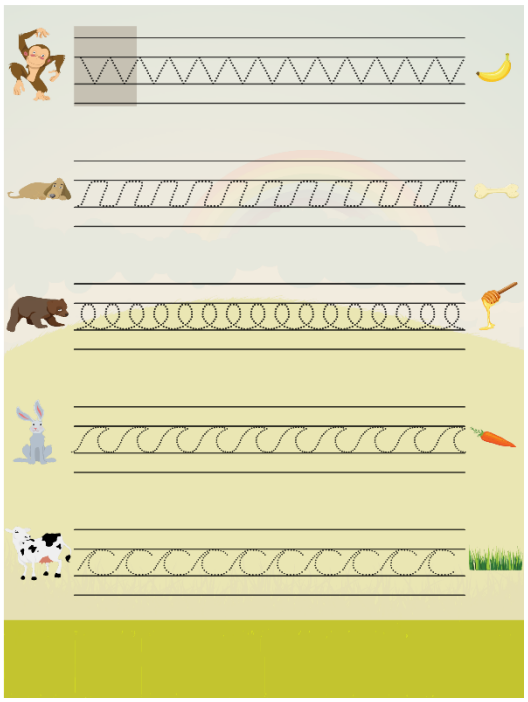

Figure 9. Trial screen

3.7.3 Main parts of the application

The main part of application consists of four different contents: 29 lowercase letters, 29 uppercase letters, 10 numbers, 386 syllabi and words. The learning objectives were selected from both Turkish MONE (2008) Specific Learning Disabilities Support Education Program (Module: Math, section: natural numbers, learning objective: "writing numbers"; Module: Literacy, the fifth Learning objective: “writing the letters”, the seventh learning objective: “writing syllabi” and the ninth learning objective: “writing words”) and MONE (2015) curriculum (Turkish first grade course, T1.3. Writing Section, Learning Objective T1.3.2. Students will be able to write letters,

numbers, and arithmetic signs accordance with the technique, Learning Objective T1.3.3. Students will be able to write illegible syllabi and words using cursive writing). The content was selected from course book (Doğan Temur, 2015), considering classroom teacher's and experts' views. A music player is on the top of the screen. Students can control it easily. The content is exhibited to students as a dart game. There is a writing line on the screen with a model of the learning objective (the letter/number/syllabi/words) and a guiding gray field to show student where to begin writing. Students with SLD have problems with confusing the directions (MONE, 2008). The gray field was developed because of this. Students are expected to write the learning objective (a letter, a number, or a word) most similar to the model and needed to do same three times correctly. Three levels of clues are exhibited by the application (Figure 10). The first clue is showing writing direction (s) of the letter/number/syllabi/words by arrows. The second clue is showing how to write the letter/number/syllabi/words by animation. In addition, showing how to write the letter/number/syllabi/words by animation, the third clue is presenting the dotted version of the letter/number/syllabi/words. When students write the learning objective three times correctly, then the other learning objective is presented. If students make a mistake, subsequent clue is presented. The type of clue changes when students make mistake for two consecutive times. For each learning objective, three arrows are given to students. For each correct correspondence, one arrow is shot and students gain a score between 88 and 100 in terms of similarity rate to the learning objective model. When the similarity rate is more than 80%, it is converted to 100 points. If the similarity rate is less than 70%, the writing is not considered accurate. Students are given an overall score out of 100. Simultaneously with these, students are given a positive/negative sound as feedback. When students write learning object for three times correctly, one of 12 verbal positive reinforcements is given randomly. Total score of students is shown at the scoreboard on top of the screen.

In addition to correct writing, line control is also checked for each learning objective by the application due to inability to adjust letter size, line and margin (Richards, 1998) considering the needs of these students and special education experts' views. When students can not follow the line and overflow the line 5 pixels, even if they write the

learning object correctly, the answer is not accepted. Students are given a verbal feedback: “You have to pay attention to the line” and the color of overflowed line (s) change(s) to red. Above-mentioned working principle of mobile writing application was presented by a flow chart (Appendix I).

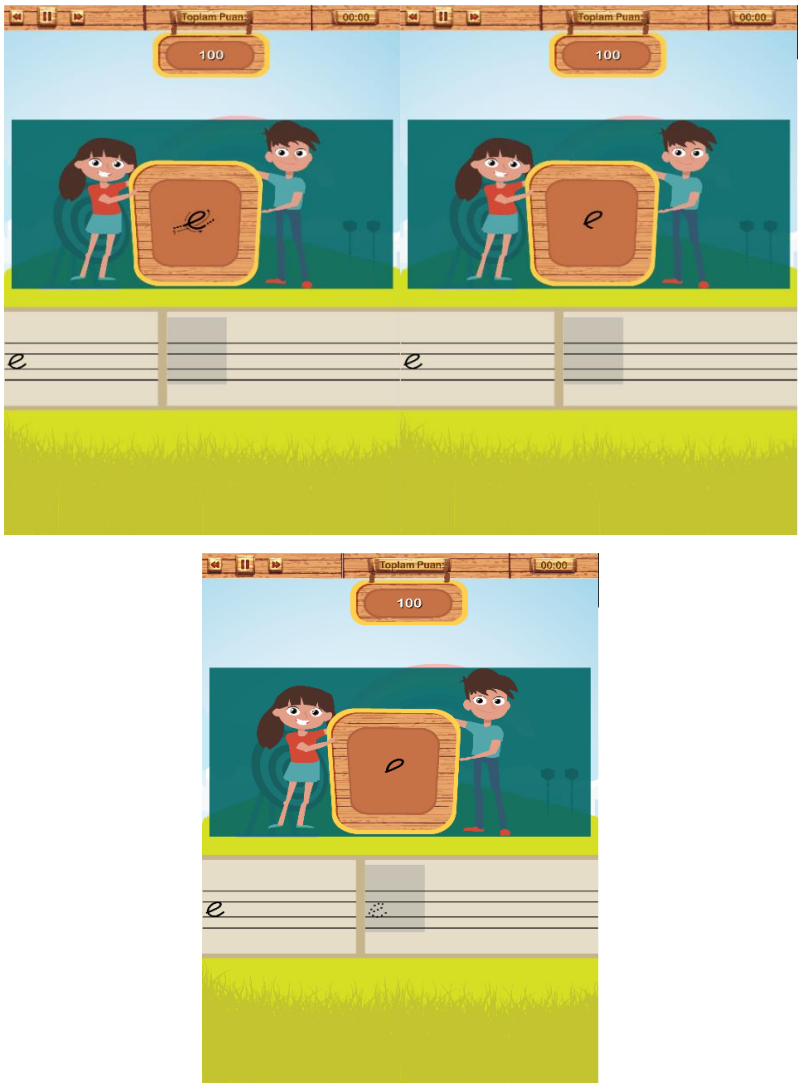

Figure 10. Screenshots from the three levels of clues: first, second and third level clues respectively

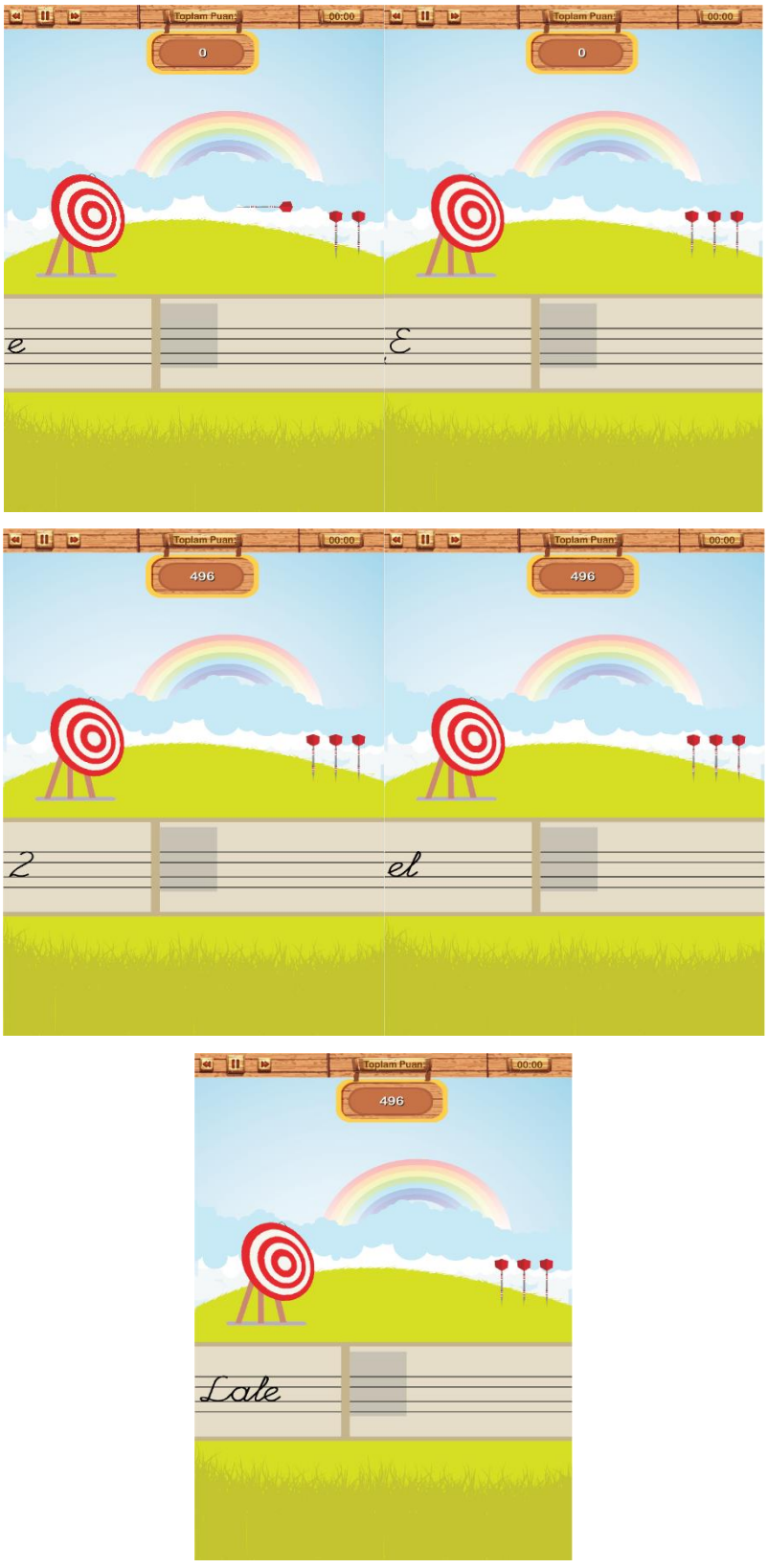

Figure 11. Screenshots from the main parts of application: lowercase letters, uppercase letters, numbers, syllables, and words parts respectively

3.7.4 Database of the application

Application database was developed by using SQLite. The study time, scores, correct uppercase and lowercase letter, incorrect uppercase and lowercase letter, correct number, incorrect number, correct syllabi, incorrect syllabi, correct word, incorrect words, clues used, percentage of correct writing, number of the lines overflowed, and names of overflowed lines were kept in the database.

3.8 Data Analysis

For research question 1, the questionnaire was analyzed through descriptive statistics (percentage). For research question 2, after calculating pretest and posttest scores, the data were analyzed through descriptive and inferential statistics by using the SPSS. The level of significance for the statistical analyses of the data in this study was set to.05. Because of the fact that the number of the students was less than 30, Wilcoxon signed ranks test was conducted to the scores of pretest and posttest. In order to conduct Wilcoxon signed ranks test, the researcher checked two assumptions (Büyüköztürk, 2011). First assumption is independent observation. It was assumed that paired observations were randomly and independently conducted. Second assumption is the distribution of the difference scores should be continuous. In this study, they were continuous. Log data were analyzed through descriptive analysis. In addition to this, a correlation test was employed in order to reveal if there is a relationship between the students' writing speeds and the number of correct attempt.

Interview data were examined by using content analysis. Content analysis attempts to reveal concepts that can explain the data. Through content analysis, we try to identify the data and reveal the truths that may be hidden within the data. (Yıldırım & Şimşek, 2013). In order to analyze data, the researcher followed qualitative analysis steps as mentioned by Bogdan and Biklen (2007): 1) preparing the data, 2) organizing the data, 3) grouping them, 4) coding the data, 5) generating a meaningful pattern. In this context, firstly, the researcher transcribed and organized interview data using MS Word. Subsequently, transcribed data were categorized in keeping with previously determined categories which were 1) perceived ease of use, 2) perceived usefulness, 3) perceived enjoyment, 4) aspects need to be improved, and 5) future use. Afterwards,

coding the data which is the key part of content analysis was made. The data were put together by creating meaningful connections. Next, findings were described by giving direct quotations. Finally, the researcher interpreted the findings.

3.9 Experimental Validity

Internal validity: "Internal validity means that observed differences on the dependent variable are directly related to the independent variable, and not due to some other unintended variable." (Fraenkel, Wallen, & Hyun, 2012, p.166). Campbell and Stanley (1963) stated that possible threats of internal validity are history, maturation, testing, and instrumentation in one-group pretest posttest design.

In current study, pretest and posttest were carried out same location and under the same conditions. It was carried out without any factor influencing students' answers in order to eliminate history effect. Each session was almost the same length; the maturation effect was controlled. Pretest and posttest were the same in order to eliminating instrumentation effect. There was at least six weeks between pretest and posttest so testing effect was eliminated.

External validity: Fraenkel et al. (2012) defined external validity as generalizability from a sample. Since the sample size was small and purposeful sample was used in this study, there was a limitation for generalization in this study.

3.10 Reliability and Validity Issues for Qualitative Part

Inter-coder reliability was defined as different researchers agree about the codes on the same text. In addition, for inter-coder agreement researcher should find another experienced researcher to cross check their codes (Creswell, 2013). In this context, the researcher worked with a research assistant from the same field in this step. She is experienced in qualitative research and a Ph.D. candidate. She was informed about the study in detailed manner. Miles and Huberman's (1994) formula was employed to calculate inter-coder reliability score. Inter-coder reliability equals to number of agreements divided by the sum of number of agreements and number of

disagreements. In this study, inter-coder reliability score was found .84 by using this formula. According to Miles and Huberman (1994), .80 is a good score.

Thick Rich Description is one of the validity strategies in qualitative research. Researchers should use rich description in their study to convey the results (Creswell, 2013). In current study, the researcher provided a detailed information about the participants and settings. Creswell and Miller (2000) mentioned that thick description gives other researchers transferring opportunity to their research contexts in order to establish credibility.

Peer debriefing or peer review is another validity strategy used in this study. Peer debriefing means that reviewing the research process by a peer reviewer who is familiar with the whole research process. In addition, peer debriefing enables researchers to add credibility to their research (Creswell & Miller, 2000). In present study, the advisor and committee members provided reviews and gave support throughout all steps of research as peer debriefers.

Disconfirming evidence is used to add credibility to this study. Creswell (2013) emphasized that in order to establish credibility, researchers should discuss negative information as well. This is important because there are different perspectives and contradictory views in real life. By discussing contrary evidence, researchers can achieve to present their results more realistic and more valid way. In current study, the researcher presented disconfirming/negative information as well as confirming/positive evidences.

CHAPTER 4

RESULTS

As mentioned in the methodology chapter, a mixed-method design which includes both quantitative and qualitative parts was employed in this study. In this chapter, both qualitative and qualitative findings were presented. Firstly, special education experts', classroom education experts', educational technology experts', classroom education experts' and the classroom education teacher's views about application before the experiment were analyzed in terms of perceived ease of use, perceived usefulness, perceived enjoyment, educational content, visual design, multimedia use and technical features. Secondly, the findings of experiment and log were given. Finally, findings of the interview with special education teachers after the experiment for in-depth analysis of the application and procedure were presented.

4.1 Research Question 1: What are the views of subject matter experts about mobile writing application before the utilization of the mobile writing application?

Special education experts', classroom education experts', educational technology experts', classroom education experts' and the classroom education teacher's views about application before the experiment were analyzed in terms of perceived ease of use, perceived usefulness, perceived enjoyment, educational content, visual design, multimedia use and technical features.

4.1.1 Perceived ease of use

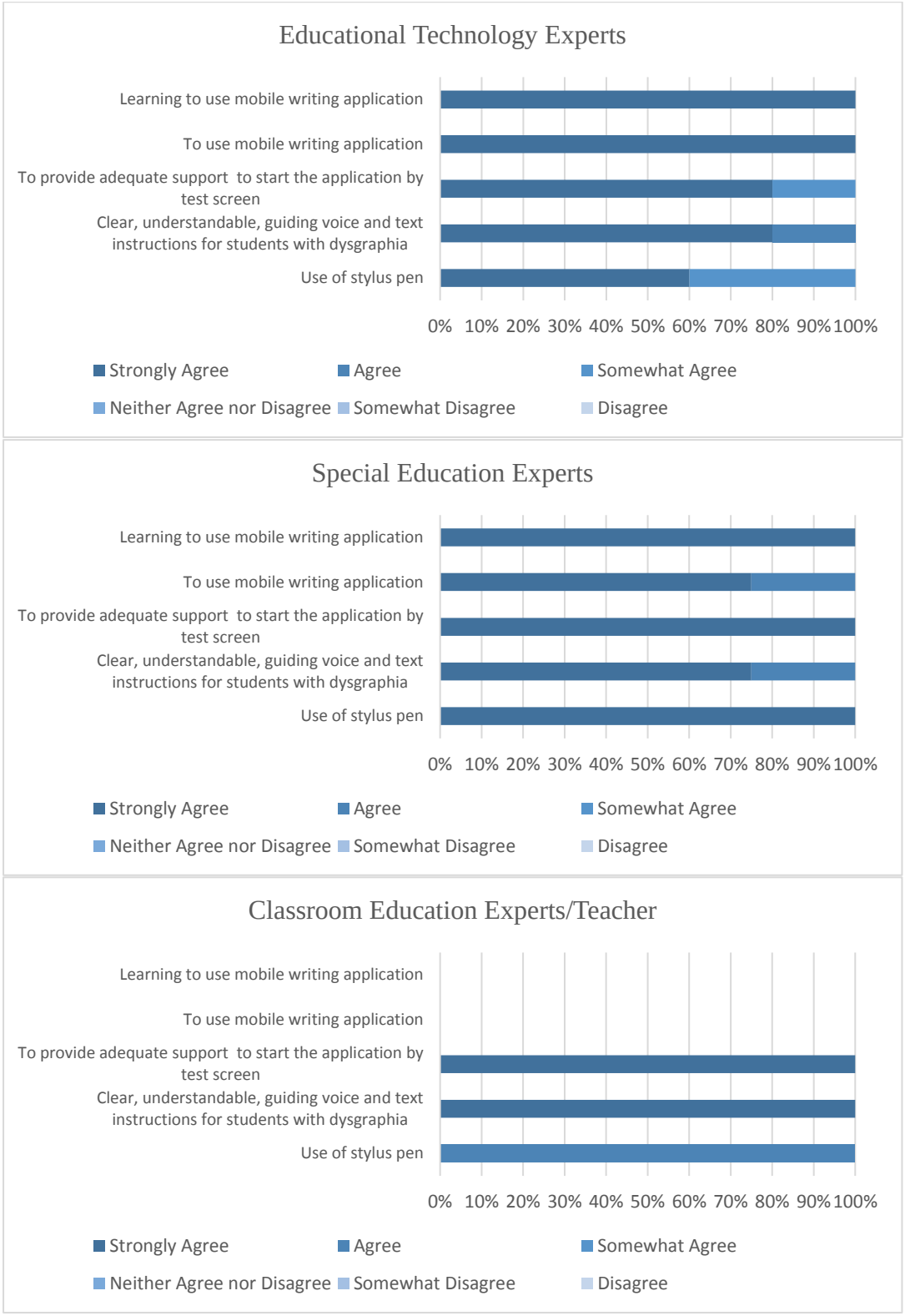

Figure 12. Experts' and the teacher's views about perceived ease of use

Educational technology and special education experts found mobile writing application easy to learning to use (*M*=5, *SD*=0). In addition, they perceived ease of use (*M*=5, *SD*=0; *M*=4.75, *SD*=0.5) both application and stylus pen (*M*=4.2, *SD*=1.1; *M*=5, *SD*=0; *M*=4, *SD*=1). All experts agreed on the need for providing adequate support to start the application by trial screen (*M*=4.6, *SD*=0.9; *M*=5, *SD*=0; *M*=5, *SD*=0). Also experts mostly agreed that application includes clear, understandable, guiding voice and text instructions for students with dysgraphia (*M*=4.8, *SD*=0.45; *M*=4.75, *SD*=0.5; *M*=5, *SD*=0).

4.1.2 Perceived usefulness

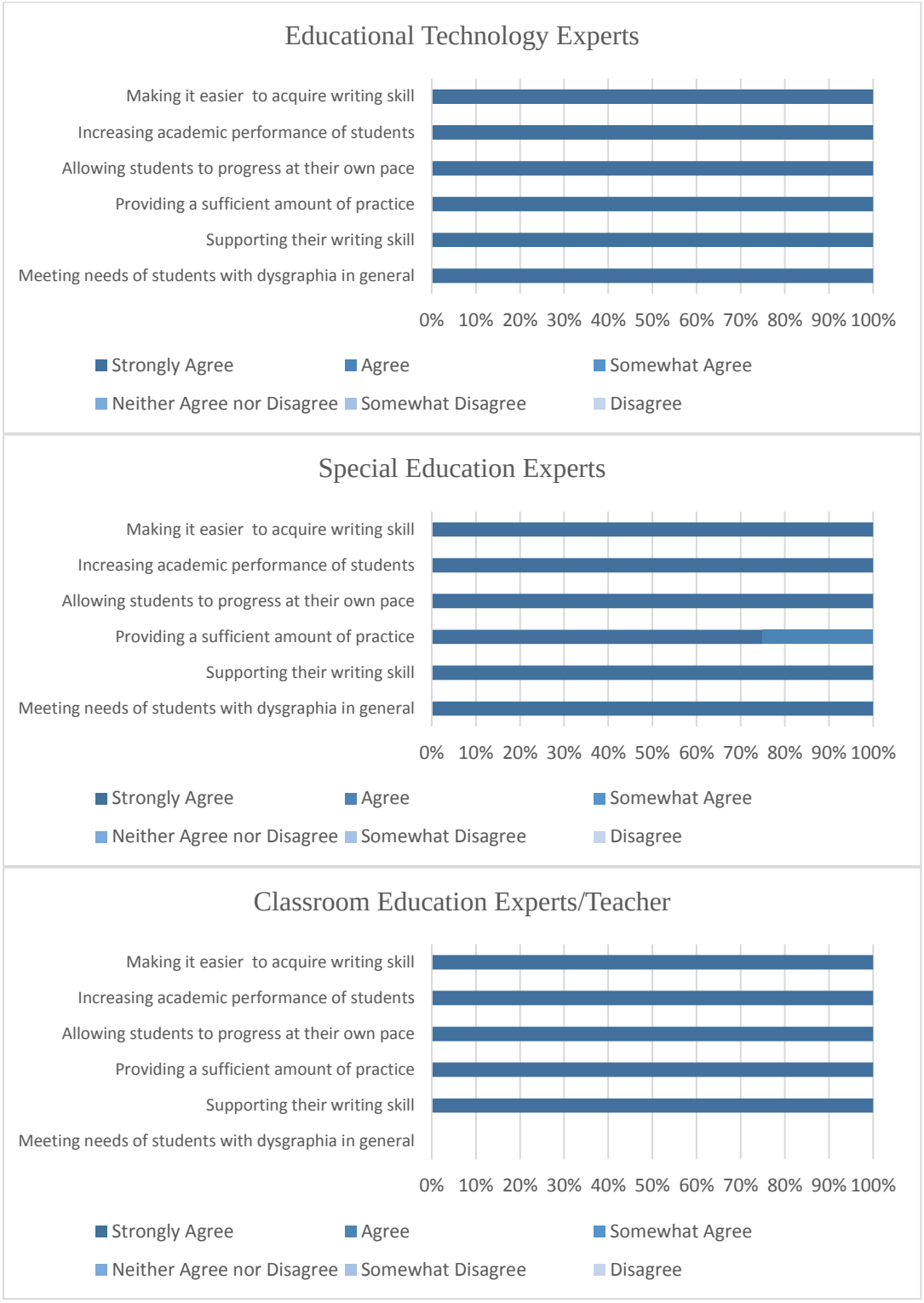

Figure 13. Experts' and the teacher's views about perceived usefulness

All experts perceived mobile writing application as useful for making it easier to acquire writing skills, increasing academic performance of students, allowing students to progress at their own pace, providing a sufficient amount of practice, and supporting their writing skill (*M*=5, *SD*=0; *M*=4.8, *SD*=05; *M*=4, *SD*=0). Also, special education experts perceived mobile writing application as useful for meeting the needs of students with dysgraphia in general (*M*=5, *SD*=0).

4.1.3 Perceived enjoyment

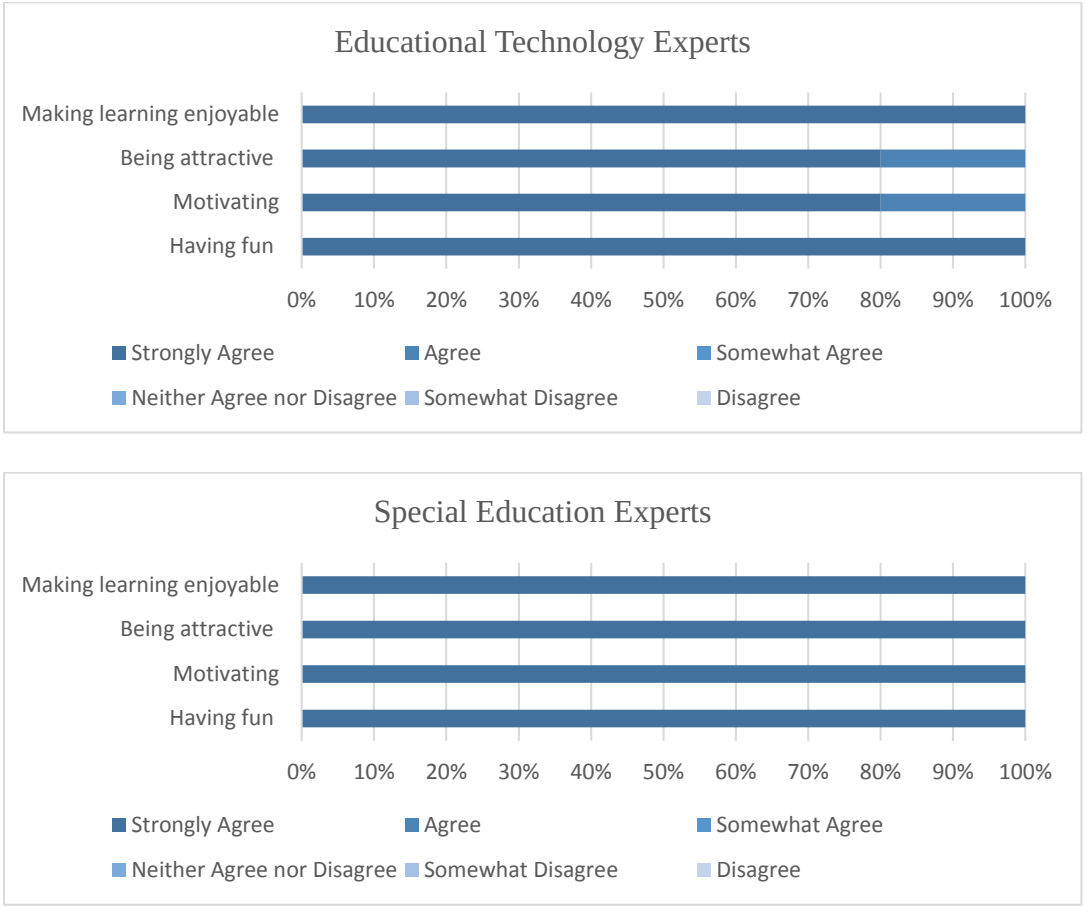

Figure 14. Experts' views about perceived enjoyment

Educational technology and special education experts thought that application makes learning enjoyable (*M*=5, *SD*=0; *M*=5, *SD*=0). Educational technology and special education experts found application attractive (*M*=4.8, *SD*=0.45; *M*=5, *SD*=0) motivating (*M*=4.8, *SD*=0.45; *M*=5, *SD*=0) and fun (*M*=5, *SD*=0; *M*=5, *SD*=0).

4.1.4 Educational content

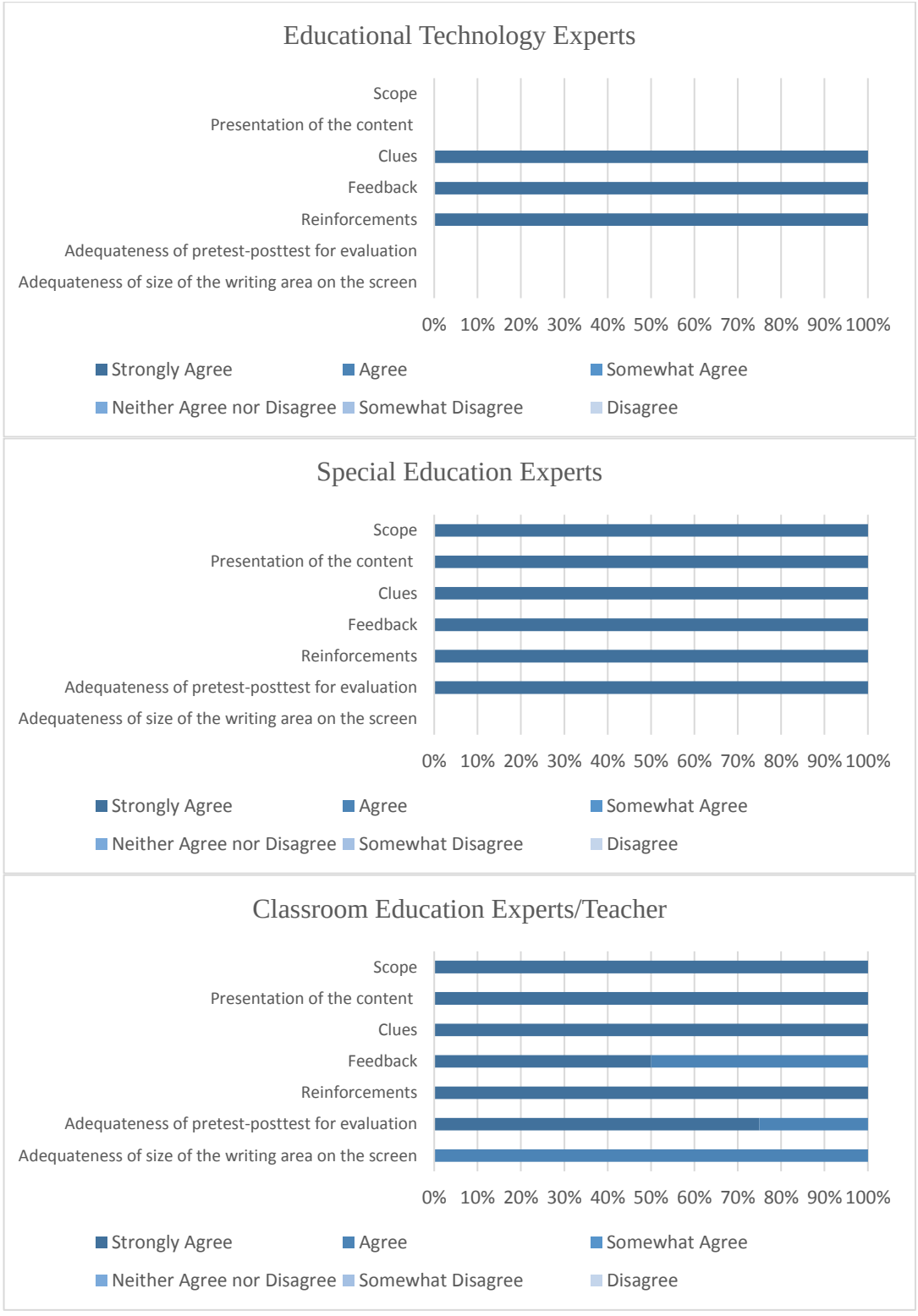

Figure 15. Experts' and the teacher's views about educational content

All interviewed experts found clues (*M*=5, *SD*=0; *M*=5, *SD*=0; *M*=5, *SD*=0), feedback (*M*=5, *SD*=0; *M*=4.5, *SD*=0.58; *M*=5, *SD*=0), reinforcements (*M*=5, *SD*=0; *M*=5, *SD*=0; *M*=5, *SD*=0) appropriate.

Special education experts and classroom education experts/teacher found scope (*M*=5, *SD*=0; *M*=5, *SD*=0), presentation of content (*M*=5, *SD*=0; *M*=5, *SD*=0), adequateness of pretest-posttest for evaluation (*M*=5, *SD*=0; *M*=4.75, *SD*=0.5) appropriate. One of classroom education expert suggested that pretest-posttest should include words which contain all letters. It does not have to be all uppercase letters. Uppercase letter should include exceptional letter (like D, N). In addition, two of classroom education experts said that changes should be made in the game of darts at different levels in order to prevent boredom.

Classroom education experts/teacher found adequateness of size of the writing area on the screen appropriate (*M*=4, *SD*=1). Three of classroom education experts emphasized that line spacing and font size should be enlarged. One of special education expert suggested that a lesser amount of learning objective (letter, word etc.) should be one line and there should be more space between learning objectives in the pretest and posttest.

4.1.5 Visual design

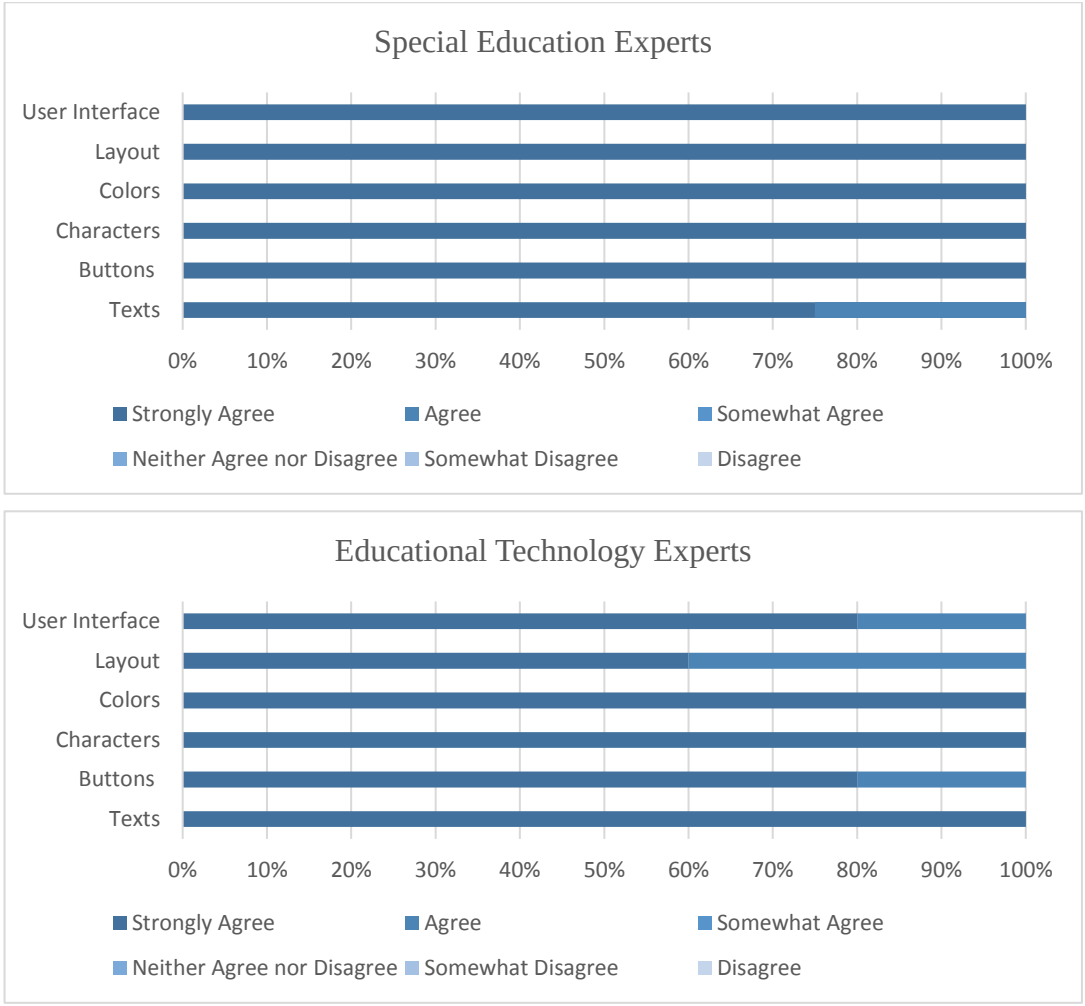

Figure 16. Experts' views about visual design

Educational technology and special education experts found user interface (*M*=4.8, *SD*=0.45; *M*=5, *SD*=0), layout (*M*=4.6, *SD*=0.55; *M*=5, *SD*=0), colors (*M*=5, *SD*=0; *M*=5, *SD*=0), characters (*M*=5, *SD*=0; *M*=5, *SD*=0), buttons (*M*=4.8, *SD*=0.45; *M*=5, *SD*=0), and texts (*M*=5, *SD*=0; *M*=4.75, *SD*=0.5) appropriate.

4.1.6 Multimedia use

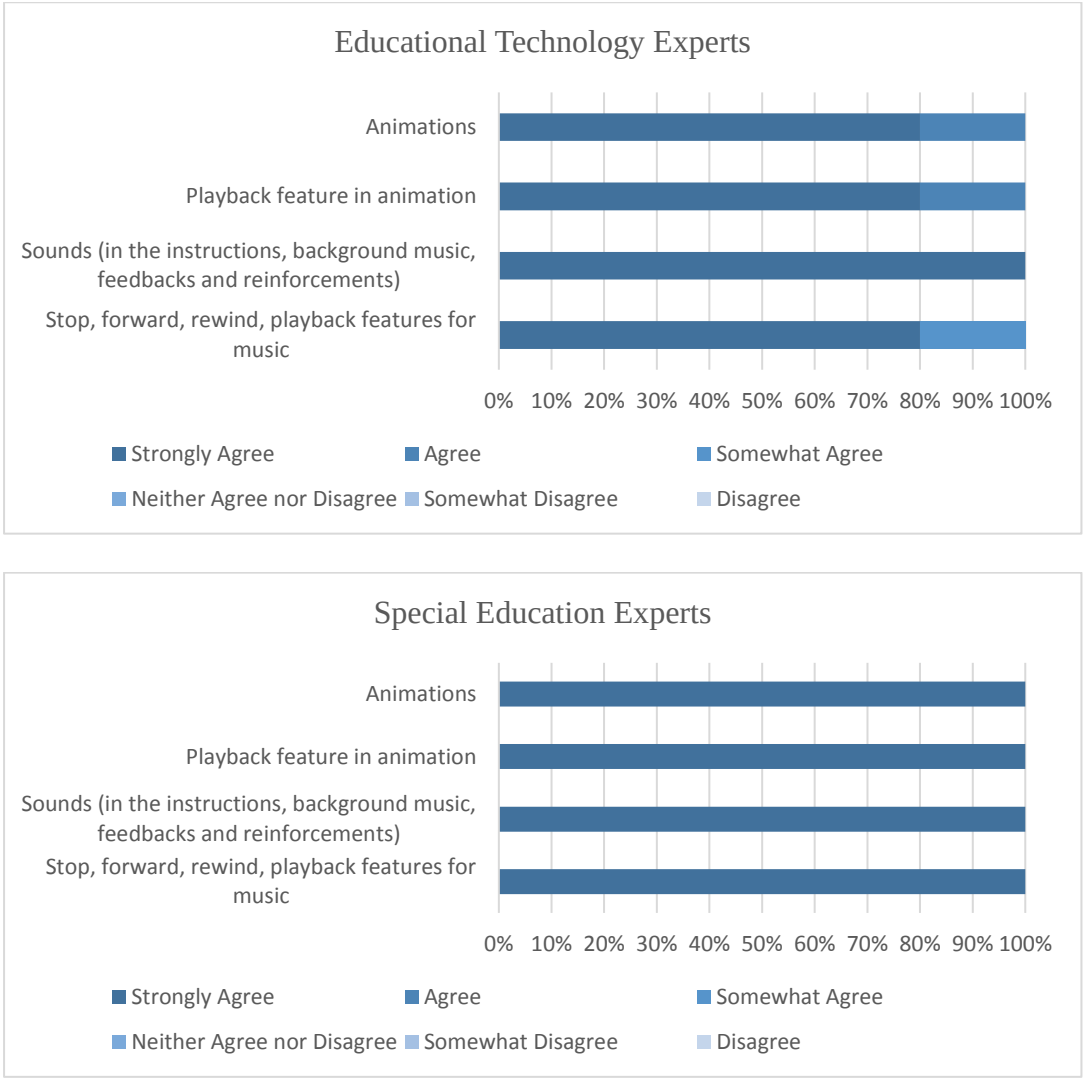

Figure 17. Experts' views about multimedia use

Educational technology and special education experts found animations (*M*=4.8, *SD*=0.45; *M*=5, *SD*=0), playback feature in animation (*M*=4.8, *SD*=0.45; *M*=5, *SD*=0), (*M*=4.6, *SD*=0.55; *M*=5, *SD*=0), sounds (*M*=5, *SD*=0; *M*=5, *SD*=0), stop, forward, rewind, playback features for music (*M*=4.8, *SD*=0.45; *M*=5, *SD*=0) appropriate. At the same time, most of educational technology experts (n=3) suggested that animations should be slower.

4.1.7 Technical features

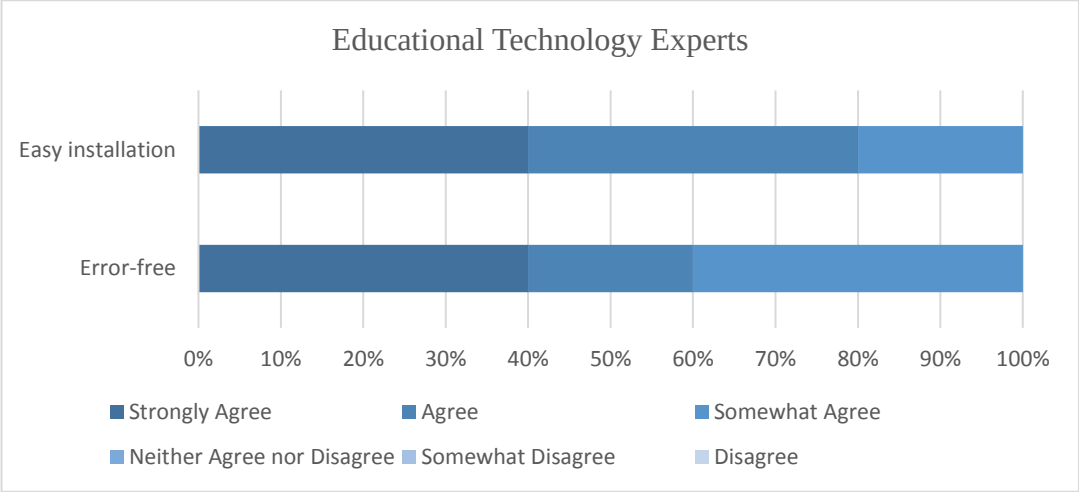

Figure 18. Experts' views about technical features

Educational technology experts found installation of application easy (*M*=4.2, *SD*=0.84) and error-free (*M*=4, *SD*=1).

4.2 Research Question 2: Does mobile writing application contribute to acquisition of writing skills (being able to write letters, numbers, syllables, and words) for students with dysgraphia?

A Wilcoxon signed ranks test was conducted to evaluate whether the mobile writing application contributed to acquire writing skills (letter, spells, and words) for students with dysgraphia.

Table 13. Wilcoxon signed ranks test results

Posttest - Pretest	N	Mean Rank	Sum of Ranks	Z	P
Negative Ranks Positive Ranks	- 11	- 6	- 66	-2,937	0,003

Table 14. Descriptive statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Pretest	11	6,2418	1,04441	5,00	8,00
Posttest	11	11,4245	1,23925	9,67	13,33

The results indicated a significant difference, $z = -2.94$, $p < .01$. The mean of the ranks in favor of posttest was 11.42, while the mean of the ranks in favor of pretest was 6.24. The mean shows that intervention had a positive impact of writing skills of students with dysgraphia.

4.3 Research Question 2.1: What are on-task behavior, writing speed, correct and incorrect attempts, line violation, and clues used of students with dysgraphia while using mobile writing application?

The log data were analyzed in terms of on-task behavior, writing speed, correct-incorrect attempts, line violations, and clues used for each students.

4.3.1 Student MAU

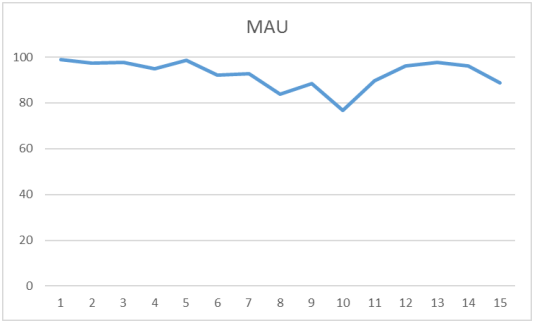

Figure 19. Percentages of on-task durations for each sessions

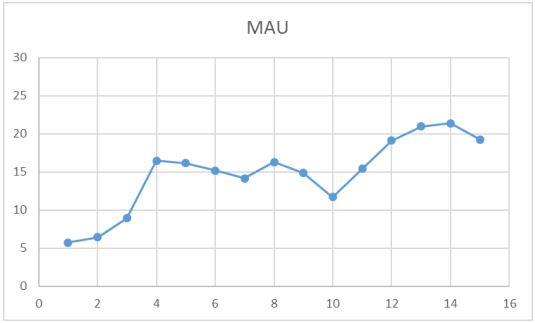

Figure 20. Writing speed (the number of written letters per minute for each sessions)

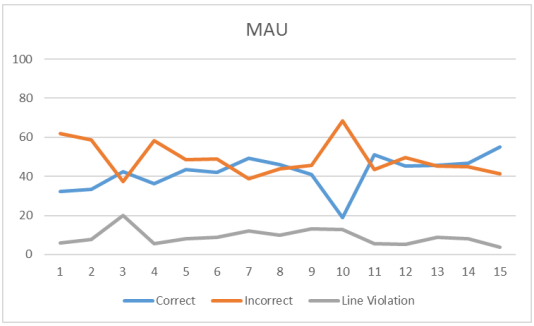

Figure 21. Percentages of correct-incorrect attempts and line violations for each sessions

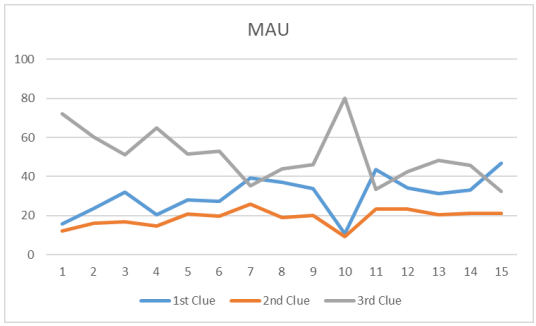

Figure 22. Percentages of three types of clues used by student for each sessions

On-task duration of MAU ranged between 80% and 100% approximately for each session except for the 10th session. As can be seen in Figure 20, there was a continuous increase in the number of letters written per minute.

Except for the 4th, the 8th, the 10th, and the 12th sessions, in all other sessions, while there was an increase in the number of correct attempts, there was a decrease in the number incorrect ones. In addition, the number of line violation decreased session by session. The most challenging targets can be seen in Table 17. The three graphs revealed an obvious decline in the 10th session. When the logs were analyzed, this

session covered the most misspelled word which was “öne” (see Table 16). Moreover, there was one of the most misspelled words which was “önde” during this session too (see Table 16). As can be seen in Figure 22, the number of third degree clues was high at the beginning and it decreased gradually. In addition, the most challenging letters for MAU can be seen in Table 15.

Table 15. Letters written wrong 10 times or more

session	target	order	Count
1	o	6	30
1	i	4	13
1	t	3	12
1	ö	15	11
1	z	19	13
2	z	19	3
2	c	22	23
2	ç	20	17
2	T	32	14
2	Z	48	10
2	H	53	9
3	H	53	10

Table 16. Syllables and words written wrong 10 times or more

session	target	order	Count
3	et	81	12
3	ete	82	1
4	ete	82	15
4	ilet	95	15
4	talat	87	15
5	Tatilini	114	15
5	atlet	122	10
5	taneli	108	10
5	narla	135	7
6	narla	135	7
6	mo	144	22
6	elma	140	10
6	otur	164	4
7	otur	164	7
8	asa	210	15
8	saat	224	11
9	masa	227	12
9	öne	249	8
10	öne	249	35
10	önde	254	11
11	önde	254	4
12	Türkü	290	15
12	aşı	298	11
13	uçtu	344	13
13	üzüm	325	12
13	gezi	354	11
14	çağa	411	14
14	İp	391	13

Table 17. Targets written with line violation 4 times or more

session	target	order	Count
1	i	4	4
2	ç	20	4
2	T	32	4
2	H	53	3
3	H	53	5
3	V	55	5
3	8	65	5
3	la	75	4
6	narla	135	5
7	ekmek	172	4
7	ey	193	4
8	Oya	208	5
9	Dede	239	6
9	Demet	237	4
10	öne	249	6

4.3.2 Student DT

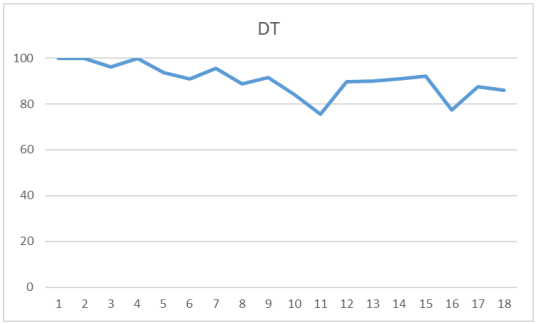

Figure 23. Percentages of on-task durations for each sessions

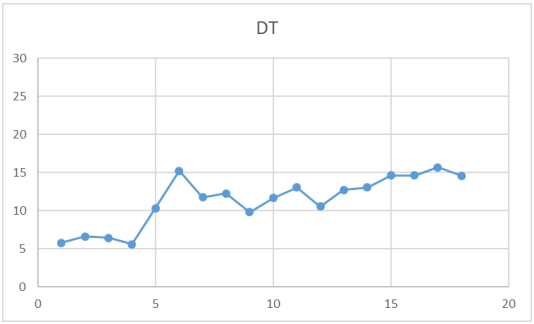

Figure 24. Writing speed (the number of written letters per minute for each sessions)

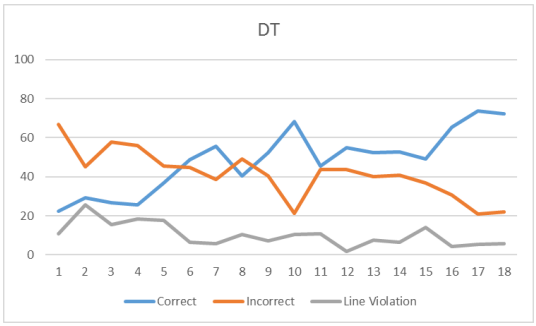

Figure 25. Percentages of correct-incorrect attempts and line violations for each sessions

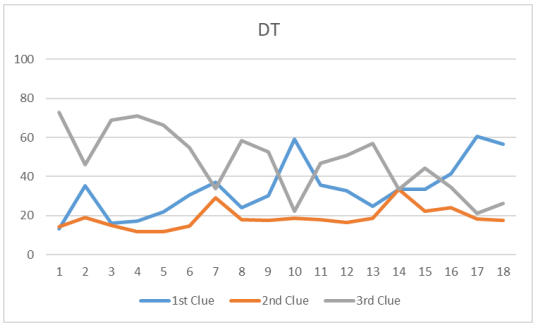

Figure 26. Percentages of three types of clues used by student for each sessions

On-task duration of DT ranged between 80% and 100% approximately for each session except for the 11th session. When the logs were analyzed, this session covered some of the most challenging words which were “saat” and “Selim” (See Table 20). As can be seen in Figure 24, there was a continuous increase in the number of letters written per minute. Except for the 8th and the 11th sessions, in all other sessions, while there was an increase in the number of correct attempts, there was a decrease in the number incorrect ones. In addition, the number of line violation decreased session by session. The most challenging targets can be seen in Table 21. As can be seen in Figure 26, the number of third degree clues was high at the beginning and it decreased gradually.

Also the most challenging letters, numbers and words for DT can be seen in Table 18, 19, and 20 respectively.

Table 18. Letters written wrong 10 times or more

session	target	order	Count
1	o	6	21
1	t	3	20
1	n	5	10
2	ö	15	10
3	İ	33	21
3	j	28	17
3	R	36	11
3	p	23	10
3	f	27	10
4	B	45	27
4	Ö	44	19
4	P	52	18
4	F	56	17
4	V	55	10

Table 19. Numbers written wrong 10 times or more

session	target	order	Count
5	8	65	22
5	9	66	10

Table 20. Syllables and words written wrong 10 times or more

session	target	order	Count
5	et	81	13
5	talat	87	9
6	talat	87	1
6	Talat	88	13
6	ilet	95	11
7	Tatilini	114	10
8	mine	142	16
8	armut	160-165	23
9	armut	160-165	7
11	Selim	219	11
11	saat	224	3
12	saat	224	13
12	su	226	12
13	öne	249	15
13	ör	247	15
15	ziya	318	14
15	çok	341	3
16	çok	341	10

Table 21. Targets written with line violation 4 times or more

session	target	order	Count
1	l	1	7
1	y	12	6
2	y	12	7
2	ç	20	5
2	g	21	4
3	g	21	2
3	İ	33	7
3	U	38	6
3	h	24	4
4	V	55	10
4	Ö	44	8
4	Ş	47	5
4	1	58	4
5	8	65	13
5	3	60	11
5	9	66	5
8	mine	142	6
15	üç	330	6
15	içe	331	4

4.3.3 Student HE

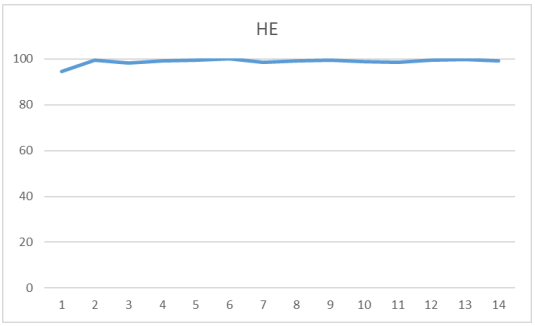

Figure 27. Percentages of on-task durations for each sessions

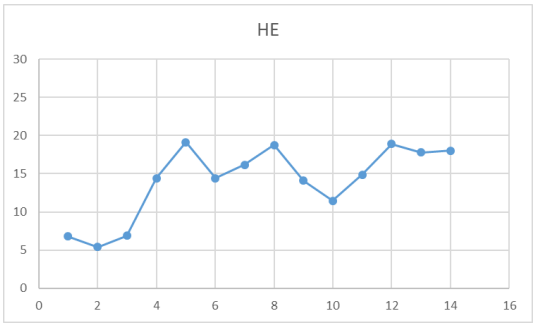

Figure 28. Writing speed (the number of written letters per minute for each sessions)

Figure 29. Percentages of correct-incorrect attempts and line violations for each sessions

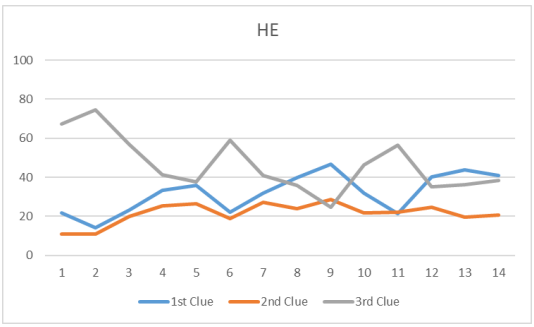

Figure 30. Percentages of three types of clues used by student for each sessions

On-task duration of HE ranged between 90% and 100% approximately for each session. As can be seen in Figure 28, there was a continuous increase in the number of letters written per minute except for the 6th and the 10th sessions. When the logs were analyzed, these sessions covered some of the most challenging words which were “mu”, “mo”, “mum”, “unu”, and “armut” in the 6th session; “düdük”, “az”, and “aş” in the 10th session (see Table 23). Except for the 6th, the 10th, and the 11th sessions, in all other sessions, while there was an increase in the number of correct attempts, there was a decrease in the number incorrect ones. In addition, the number of line violations decreased session by session. The most challenging targets can be seen in

Table 24. As can be seen in Figure 30, the number of third degree clues was high at the beginning and it decreased gradually. In addition, the most challenging letters for HE can be seen in Table 22.

Table 22. Letters written wrong 10 times or more

session	target	order	count
1	i	4	21
1	a	2	15
1	t	3	11
2	ö	15	21
2	c	22	12
2	ş	18	12
2	p	23	11
2	ü	17	11
2	j	28	15
3	j	28	5
3	K	39	18

Table 23. Syllables and words written wrong 10 times or more

session	target	order	count
4	in	99	13
5	mo	144	5
6	mo	144	9
6	mu	155	29
6	armut	160-165	11
10	düdük	292	14
10	az	314	6
11	az	314	7
11	üç	330	24
11	Kiraz	326	20
12	ip	375	9
13	ip	375	5
13	çağa	411	16
13	çiğ	419	3
14	çiğ	419	11
14	verdi	428	10
14	ef	431	10

Table 24. Targets written with line violation 4 times or more

session	target	order	count
3	D	43	8
3	G	50	8
3	L	30	6
3	C	51	5
3	J	57	5
3	9	66	4
3	0	67	3
4	0	67	2
5	mo	144	1
6	mo	144	5
6	mum	162	8
6	unu	152	6
7	Yener	200	10
7	Uyan	204	4
8	suya	221	4
10	aş	295	6
11	Yaz	322	5
12	Ege	349	4

4.3.4 Student MAC

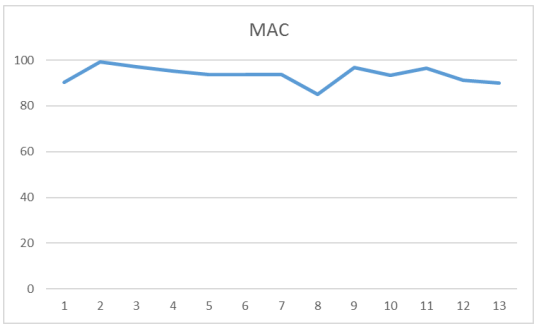

Figure 31. Percentages of on-task durations for each sessions

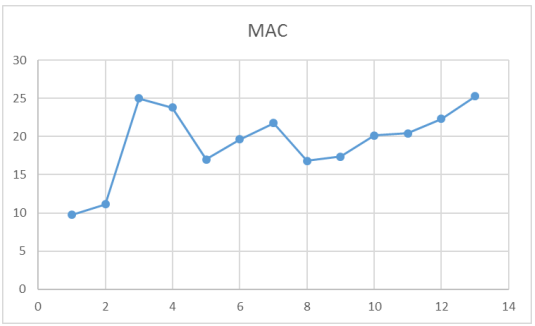

Figure 32. Writing speed (the number of written letters per minute for each sessions)

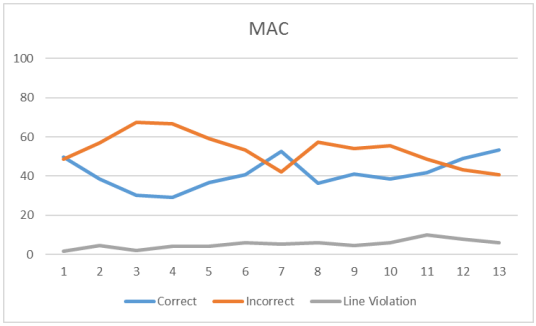

Figure 33. Percentages of correct-incorrect attempts and line violations for each sessions

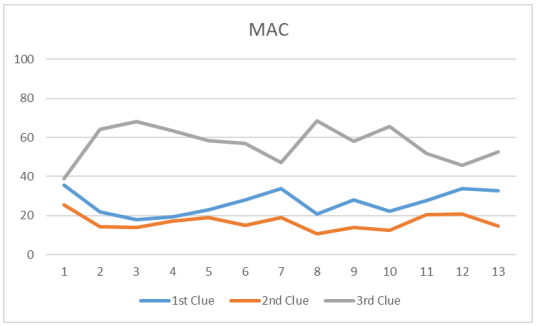

Figure 34. Percentages of three types of clues used by student for each sessions

On-task duration of MAC ranged between 80% and 100% approximately for each session. Yet, there is an obvious decrease in the 8th session compared to other sessions. As can be seen in Figure 32, there was a continuous increase in the number of letters written per minute except for the 5th and the 8th sessions. When the logs were analyzed, this session covered some of the most challenging words which were “narla”, “mo”, “irem”, “limon”, and “armut” in the 5th session; “öner”, “öne”, “önde”, “ör”, and “öt” in the 8th session (see Table 27). Except for the 8th session, in all other sessions, while there was an increase in the number of correct attempts, there was a decrease in the number incorrect ones. In addition, the number of line violation

decreased session by session. The most challenging targets can be seen in Table 28. In addition, the most challenging letters and number for MAC can be seen in Table 25 and 26 respectively.

Table 25. Letters written wrong 10 times or more

Session	target	order	count
2	K	39	25
2	F	56	25
2	T	32	18
2	c	22	14
2	p	23	10
2	Z	48	10

Table 26. Numbers written wrong 10 times or more

session	target	order	count
2	9	66	12

Table 27. Syllables and words written wrong 10 times or more

session	target	order	count
2	ata	80	27
2	et	81	11
2	at	79	10
2	atla	85	12
3	atla	85	11
3	talat	87	28
3	Tan	112	17
3	eti	94	15
3	Talat	88	12
3	ite	96	10
3	ilet	95	10
4	Tatilini	114	22
4	atlet	122	17
4	rana	133	11
4	Nalan	120	10
4	oto	117	10
4	narla	135	9
5	narla	135	9
5	mo	144	15
5	irem	146	14
5	limon	148	12
5	armut	160-165	11
6	armut	160-165	1
6	urmak	178	25
6	Kemal	173	23
7	yatma	206	25
8	Öner	251	20
8	öne	249	14
8	ön	246	14

Table 27. (continued)

session	target	order	count
8	öt	248	11
8	ör	247	11
8	önde	254	8
9	önde	254	2
9	ömer	256	19
9	türk	276	15
9	Ünal	280	14
9	tül	286	10
10	tül	286	4
10	Türkü	290	20
10	Şeyda	307	16
10	küsme	287	14
10	taşı	300	10
11	üzüm	325	21
11	Kiraz	326	14
11	Taze	320	14
11	Ziya	319	12
12	Karga	360	10
13	Çağan	412	24
13	Fatma	440	16
13	verdi	428	11

Table 28. Targets written with line violation 4 times or more

session	target	order	count
2	9	66	4
8	öne	249	5
8	öner	250	4
11	Ziya	319	9
11	üzüm	325	5
11	ziya	318	4
12	yonca	372	4
12	hakan	396	2
13	hakan	396	5

4.3.5 Student RS

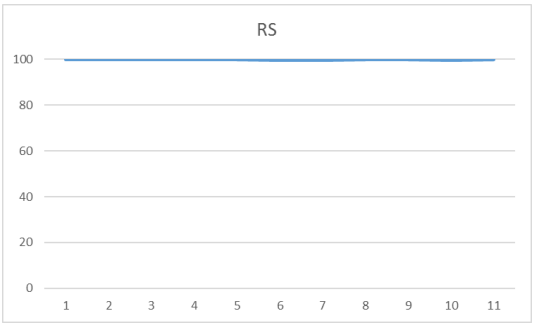

Figure 35. Percentages of on-task durations for each sessions

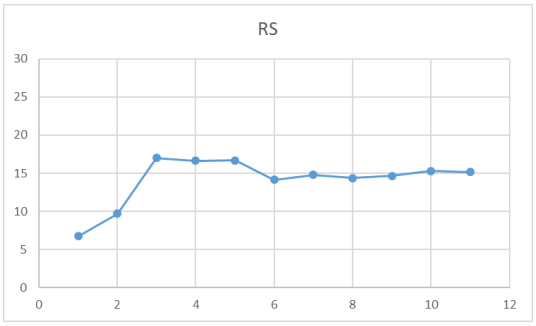

Figure 36. Writing speed (the number of written letters per minute for each sessions)

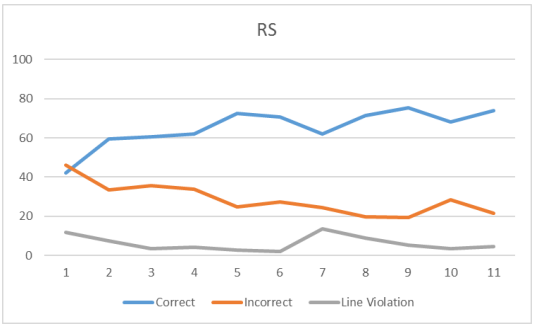

Figure 37. Percentages of correct-incorrect attempts and line violations for each sessions

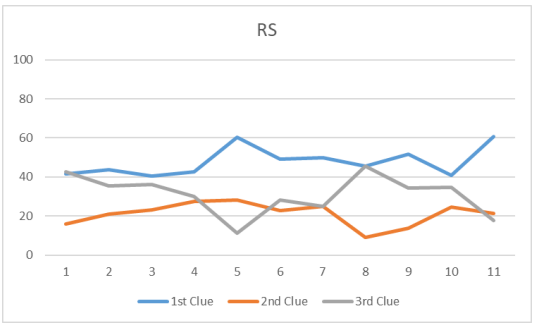

Figure 38. Percentages of three types of clues used by student for each sessions

On-task duration of RS was 100% approximately for each session. As can be seen in Figure 36, there was a continuous increase in the number of letters written per minute. Except for the 7th and the 10th sessions, in all other sessions, while there was an increase in the number of correct attempts, there was a decrease in the number incorrect ones. In addition, the number of line violation decreased session by session except for the 7th one. When the logs were analyzed, this session covered some of the most challenging letters for line violation which were "ü" and "ş" (see Table 31). There was a decrease in the number of correct attempts because of line violation in the 7th session. As can be seen in Figure 38, the number of first, second, and third degree clues

are almost same. In addition, the most challenging letters and words for RS can be seen in Table 29 and 30 respectively.

Table 29. Letters written wrong 10 times or more

session	target	order	count
1	v	26	13
2	T	32	17

Table 30. Syllables and words written wrong 10 times or more

session	target	order	count
3	Tatilini	114	11
3	ar	125	2
4	ar	125	9
8	üç	330	10
8	Ege	349	10

Table 31. Targets written with line violation 4 times or more

session	target	order	count
1	ç	20	9
1	j	28	4
2	9	66	5
2	Y	41	4
3	in	99	5
7	eş	297	9

4.3.6 Student GS

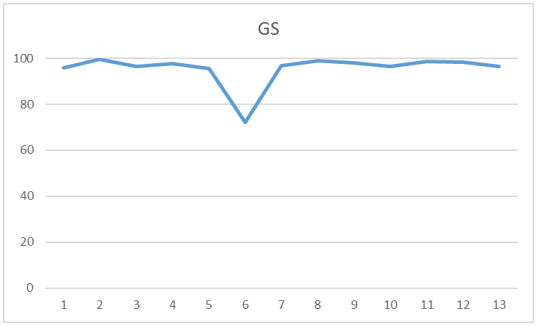

Figure 39. Percentages of on-task durations for each sessions

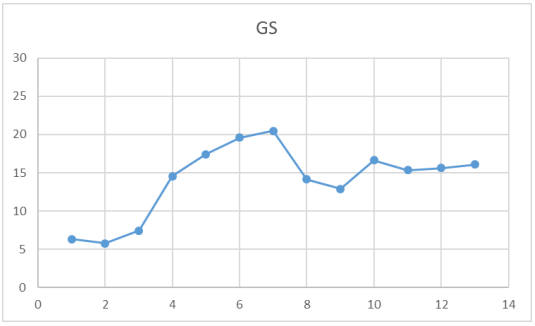

Figure 40. Writing speed (the number of written letters per minute for each sessions)

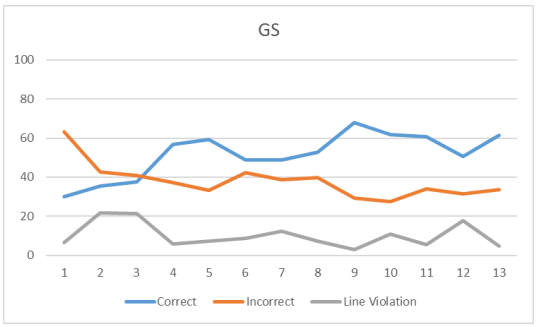

Figure 41. Percentages of correct-incorrect attempts and line violations for each sessions

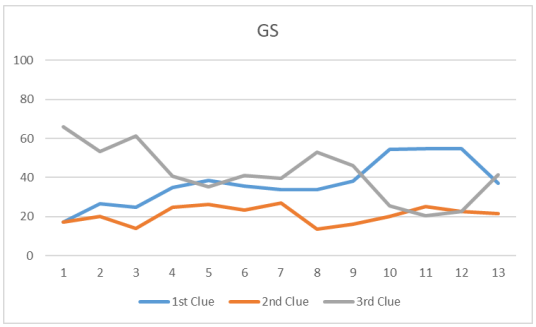

Figure 42. Percentages of three types of clues used by student for each sessions

On-task duration of GS was 100% approximately for each session except for the 6th one. His mother could not come with him the day the 6th session. That is why there is a decrease his on-task time on that day. It can be said that it also had an effect on decreasing the number of correct attempts. As can be seen in Figure 40, there was a continuous increase in the number of letters written per minute except for the 8th session. When the logs were analyzed, this session covered some of the most challenging words which were “öne”, “dök”, and “suya” (see Table 33). There was a decrease in the number of correct attempts because of line violation in the 10th and the 12th sessions. Except for 6th, 10th, and 12th sessions, in all other sessions, while there

was an increase in the number of correct attempts, there was a decrease in the number incorrect ones. In addition, the number of line violation decreased session by session except for the 10th and the 12th ones (see Table 34). As can be seen in Figure 42, the number of third degree clues was high at the beginning and it decreased gradually. In addition, the most challenging letters for GS can be seen in Table 32.

Table 32. Letters written wrong 10 times or more

session	target	order	count
1	a	2	16
1	r	7	13
1	t	3	12
1	i	4	10
2	ş	18	16
2	c	22	10
3	P	52	18
3	F	56	16
3	Ş	47	10

Table 33. Syllables and words written wrong 10 times or more

session	target	order	count
4	et	81	10
6	armut	160-165	10
7	suya	221	11
8	öne	249	17
8	dök	260	1
9	dök	260	18

Table 34. Targets written with line violation 4 times or more

session	target	order	count
1	l	1	4
2	Y	41	9
2	U	38	8
2	ş	18	6
3	Ş	47	8
3	G	50	7
3	8	65	6
6	Onur	163	4
7	Uyan	204	7
7	suya	221	2
8	suya	221	2
9	şı	299	1
10	şı	299	5
10	çok	341	3
11	çok	341	1
12	hakan	396	8
12	ah	392	4

4.3.7 Student SC

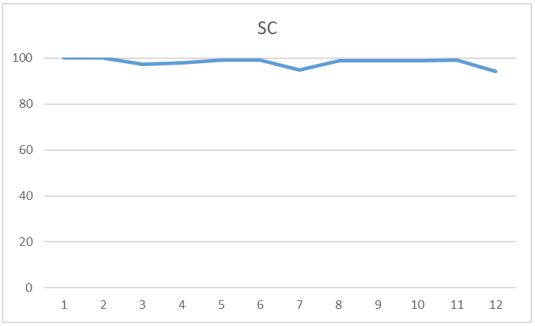

Figure 43. Percentages of on-task durations for each sessions

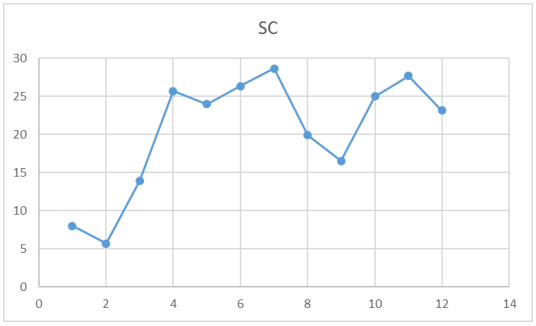

Figure 44. Writing speed (the number of written letters per minute for each sessions)

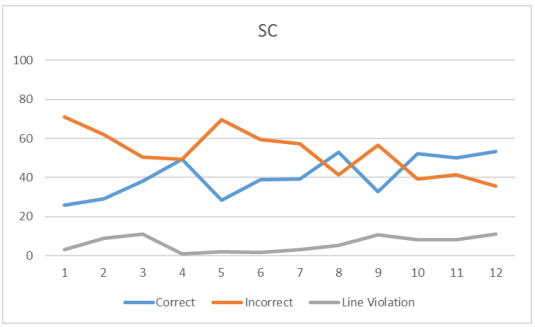

Figure 45. Percentages of correct-incorrect attempts and line violations for each sessions

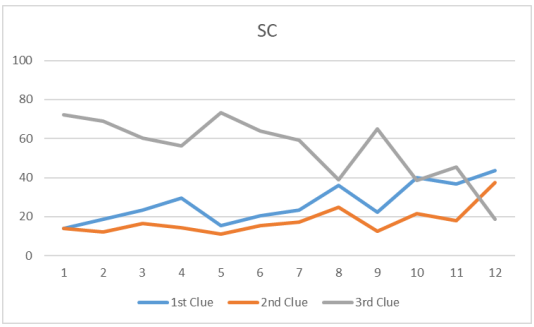

Figure 46. Percentages of three types of clues used by student for each sessions

On-task duration of SC ranged between 90% and 100% approximately for each session. As can be seen in Figure 44, there was a continuous increase in the number of letters written per minute except for the 8th and the 9th sessions. When the logs were analyzed, the 8th session covered 25 words, including the most challenging letters which were “ö” and “k” (eight times) (see Table 35). In addition, the 9th session included “iş”, “şey”, “şı”, “taşı”, “üzüm”, “muz”, “taze”, and “yürü” (see Table 37). Except for the 5th, the 9th, and the 11th sessions, in all other sessions, while there was an increase in the number of correct attempts, there was a decrease in the number incorrect ones. In addition, a small number of line violation observed in all sessions.

The most challenging targets can be seen in Table 38. As can be seen in Figure 46, the number of third degree clues was high at the beginning and it decreased gradually. Also the most challenging number for SC can be seen in Table 36.

Table 35. Letters written wrong 10 times or more

session	target	order	count
1	n	5	17
1	o	6	16
1	a	2	14
1	i	4	11
1	t	3	10
2	ç	20	20
2	N	34	20
2	ö	15	19
2	v	26	16
2	g	21	12
2	ş	18	11
3	K	39	18
3	F	56	11

Table 36. Numbers written wrong 10 times or more

session	target	order	count
3	8	65	12
3	9	66	16

Table 37. Syllables and words written wrong 10 times or more

session	target	order	count
3	at	79	19
4	talat	87	27
4	er	124	10
5	mut	156	46
5	mama	150	12
5	rana	133	11
5	mon	145	10
5	armut	160-165	40
6	armut	160-165	56
6	mutlu	166	28
6	urmak	178	10
7	astı	213	22
7	od	231	15
7	yatma	206	14
7	öt	248	11
7	sus	228	11
9	iş	296	19
9	taşı	300	16
9	şı	299	15
9	şey	305	13
9	yürü	294	11
9	üzüm	325	4
10	üzüm	325	9
11	fe	438	12
12	fe	438	2

Table 38. Targets written with line violation 4 times or more

session	target	order	count
2	L	30	5
3	8	65	7
3	9	66	7
9	muz	324	7
9	şey	305	4
9	taze	323	4
10	üç	330	5
11	Ah	393	6

4.3.8 Student BY

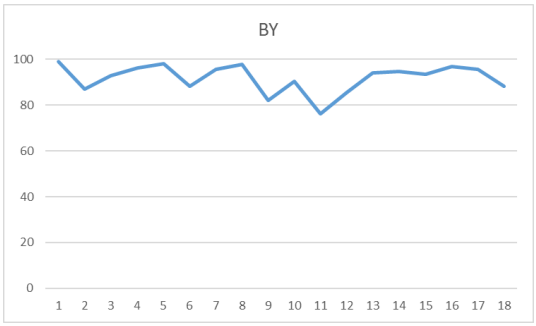

Figure 47. Percentages of on-task durations for each sessions

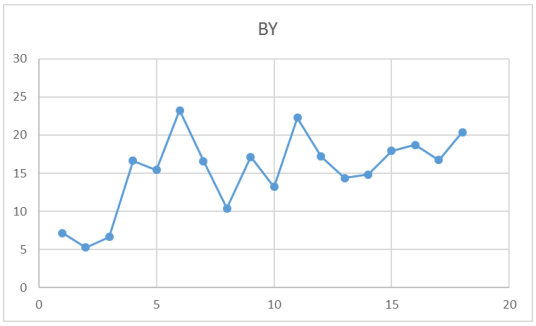

Figure 48. Writing speed (the number of written letters per minute for each sessions)

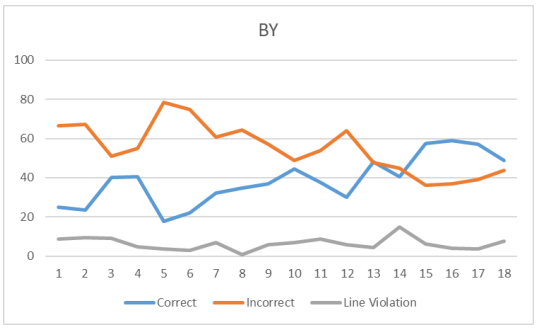

Figure 49. Percentages of correct-incorrect attempts and line violations for each sessions

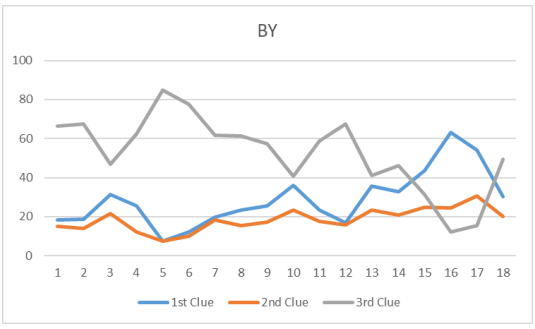

Figure 50. Percentages of three types of clues used by student for each sessions

On-task duration of BY ranged between 80% and 100% approximately for each session except for the 11th one. When the logs were analyzed, the 11th session covered all words including one of the most challenging letters, “s” (see Table 39). As can be seen in Figure 48, there was a continuous increase in the number of letters written per minute except for the 7th, the 8th, the 10th, the 12th, and the 13th sessions. When the logs were analyzed, this session covered some of the most challenging words which were “rana”,” Rana”, “narlar”, and “atlet” in the 7th session; “armut”, “mu”, and “tut” in the 8th session; “Öner”, “radyo”, “öner”, “öt”, and” dö” in the 12th session;” önde”, and “dö” in the 13th session (see Table 40). Besides, the 10th session covered 18

words including one of the most challenging letters, “y” (7 times). Except for the 5th, the 12th, the 14th, and the 18th sessions, in all other sessions, while there was an increase in the number of correct attempts, there was a decrease in the number incorrect ones. In addition, a small number of line violation observed in all sessions except for the 14th one (see Table 41). As can be seen in Figure 50, the number of third degree clues was high at the beginning and it decreased gradually.

Table 39. Letters written wrong 10 times or more

session	target	order	count
1	o	6	21
1	s	13	15
1	ü	17	14
1	k	10	11
1	ö	15	10
1	I	11	10
1	ş	18	7
2	ş	18	4
2	ç	20	22
2	K	39	17
2	U	38	12
2	c	22	12
2	M	37	11
2	j	28	11
2	z	19	10
2	Y	41	8
3	Y	41	3
3	D	43	14

Table 40. Syllables and words written wrong 10 times or more

session	target	order	count
4	talat	87	23
4	ali	90	13
4	ta	84	11
4	ata	80	11
4	Talat	88	10
5	anne	104	43
5	ilet	95	36
5	ini	102	15
5	ite	96	12
5	ana	100	10
5	nine	105	8
6	nine	105	2
6	taneli	108	25
6	ot	115	19
6	Tatilini	114	16
6	Tan	112	15
6	tat	110	14
6	Nil	113	12
6	oto	117	12
6	etli	109	10
6	atlet	122	4
7	atlet	122	8
7	Rana	134	17
7	narlar	136	14
7	rana	133	13

Table 40. (continued)

session	target	order	count
7	narla	135	11
7	imi	139	11
8	mut	156	25
8	mu	155	10
8	tut	157	10
8	armut	160-165	8
9	armut	160-165	22
9	anı	179	11
9	ok	167	10
11	masa	227	32
11	saat	224	14
11	suya	221	11
12	öner	250	14
12	Öner	251	13
12	öt	248	12
12	radyo	244	11
12	dö	252	6
13	dö	252	5
13	önde	254	19
14	taşı	300	13
14	eşe	304	10
15	üç	330	14
18	ef	431	11
18	Fatih	434	10

Table 41. Targets written with line violation 4 times or more

session	target	order	count
1	k	10	6
2	ç	20	6
2	L	30	4
2	İ	33	4
2	U	38	4
3	Y	41	5
3	J	57	5
14	eşe	304	9
14	kaşı	301	4
14	şe	303	4

4.3.9 Student KH

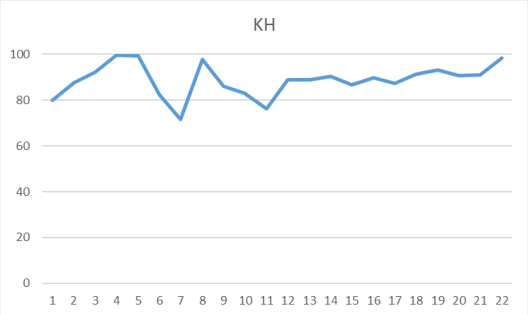

Figure 51. Percentages of on-task durations for each sessions

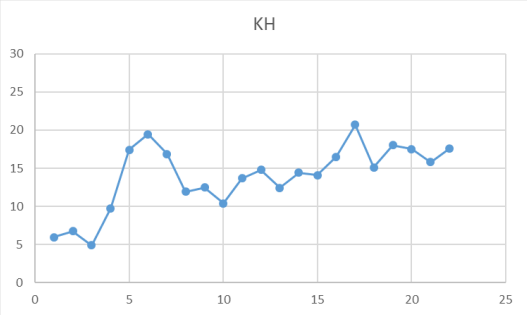

Figure 52. Writing speed (the number of written letters per minute for each sessions)

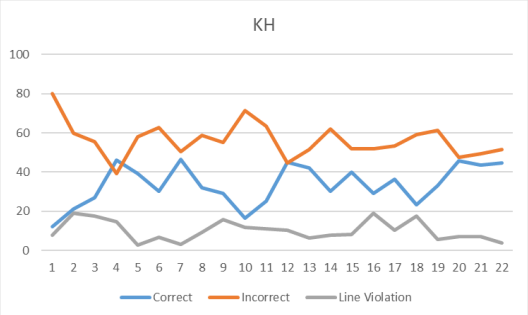

Figure 53. Percentages of correct-incorrect attempts and line violations for each sessions

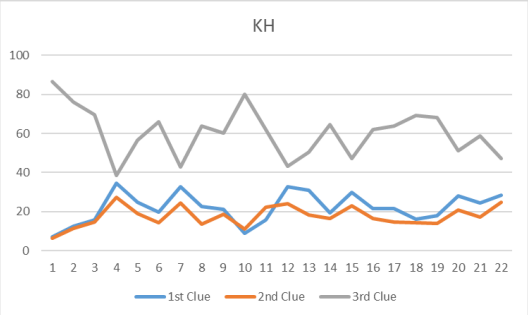

Figure 54. Percentages of three types of clues used by student for each sessions

On-task duration of KH ranged between 80% and 100% approximately for each session except for the 7th and the 11th sessions. When the logs were analyzed, the 7th session covered eight words including the second most challenging letter, “a”, while the 11th session covered 6 words including one of the most challenging letters, “k” (see Table 42). In line with this, a decrease in the number of letters written per minute was observed. As can be seen in Figure 52, there was a continuous increase in the number of letters written per minute except for the 7th, the 8th, and the 18th sessions. When the logs were analyzed, these sessions covered some of the most challenging words which were “imi”, “mon”, and “limon” in the 8th session; “çe”, “üç”, “çizme”,

and “uç” in 18th session (see Table 43). Except for the 6th, the 8th, the 10th, the 14th, the 16th, and the 18th sessions, in other sessions, while there was an increase in the number of correct attempts, there was a decrease in the number incorrect ones. In addition, the number of line violation decreased session by session except for the 9th, the 16th, and the 18th ones (see Table 44).

Table 42. Letters written wrong 10 times or more

session	target	order	count
1	a	2	59
1	o	6	32
2	o	6	34
2	ç	20	28
2	ö	15	21
2	c	22	16
2	k	10	16
3	D	43	25
3	j	28	16
3	T	32	11
3	N	34	11
3	B	45	6
4	B	45	9
4	Z	48	10

Table 43. Syllables and words written wrong 10 times or more

session	target	order	count
5	talat	87	13
5	nane	103	10
6	Tatilini	114	26
6	taneli	108	19
8	imi	139	19
8	mon	145	13
8	limon	148	11
9	tut	157	12
9	un	151	12
9	mu	155	10
9	armut	160-165	2
10	armut	160-165	10
9	otur	164	3
10	otur	164	8
10	ok	167	26
10	oku	169	20
10	mutlu	166	14
11	Kemal	173	13
11	urmak	178	12
11	anı	179	10
12	anı	179	9
13	su	226	14
14	Öner	251	19
14	di	238	14
14	dö	252	13
14	öne	249	12
14	ön	246	12
15	Türk	277	15
15	sü	282	11

Table 43. (continued)

session	target	order	count
15	ünal	279	10
15	tül	286	3
16	tül	286	7
16	taşı	300	21
16	şey	305	17
17	az	314	14
17	şarkı	310	13
18	çe	332	28
18	üç	330	17
18	çizme	339	16
18	uç	328	12
19	açtı	342	26
19	ge	350	15
20	cey	369	15
21	çağa	411	26
21	ağ	406	10
22	fi	437	10

Table 44. Targets written with line violation 4 times or more

session	target	order	count
1	a	2	4
1	o	6	2
2	o	6	8
2	ç	20	16
2	k	10	7
2	h	24	2
3	h	24	3
3	j	28	5
3	D	43	5
3	L	30	4
3	N	34	4
4	H	53	9
4	J	57	7
8	mon	145	5
9	Onur	163	7
10	ok	167	7
11	Kemal	173	6
12	Yener	200	6
14	Dede	239	4
16	taşı	300	10
16	şı	299	8
16	şey	305	6
17	şarkı	310	4
17	ziya	318	4
18	çe	332	14
18	üç	330	4
19	açtı	342	4

4.3.10 Student MYP

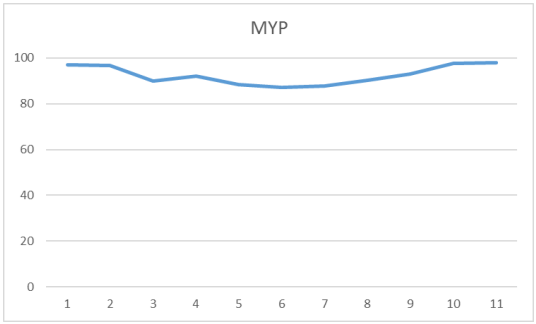

Figure 55. Percentages of on-task durations for each sessions

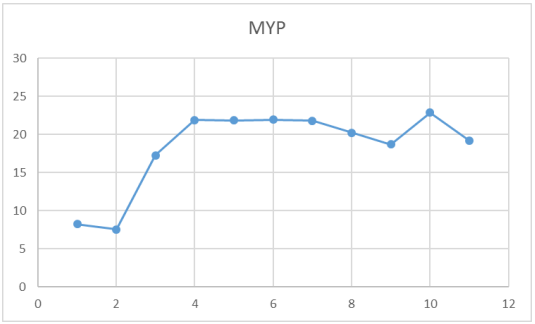

Figure 56. Writing speed (the number of written letters per minute for each sessions)

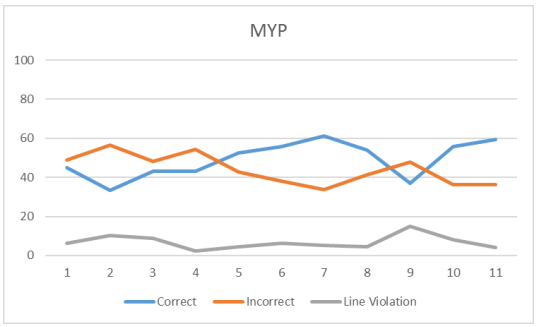

Figure 57. Percentages of correct-incorrect attempts and line violations for each sessions

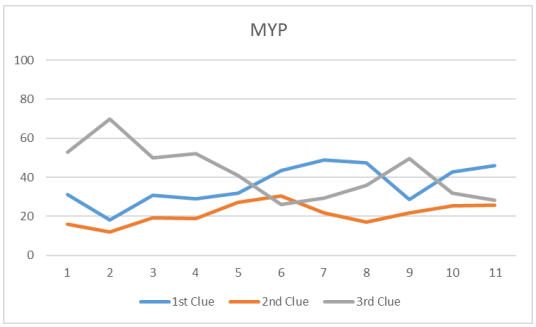

Figure 58. Percentages of three types of clues used by student for each sessions

On-task duration of MYP ranged between 80% and 100% approximately for each session. As can be seen in Figure 56, there was a continuous increase in the number of letters written per minute except for the 8th, the 9th, and the 11th sessions. When the logs were analyzed, these sessions covered some of the most challenging words which were “önde” in the 8th session; “Kiraz”, “az”, “üç”, “çizme”, and “çok” in the 9th session; “ef” in the 11th session (see Table 46). Except for the 2nd and the 9th sessions, in all other sessions, while there was an increase in the number of correct attempts, there was a decrease in the number incorrect ones. In addition, the number of line violation decreased session by session except for the 9th one (see Table 47). As can be

seen in Figure 58, the number of third degree clues was high at the beginning and it decreased gradually. In addition, the most challenging letters for MYP can be seen in Table 45.

Table 45. Letters written wrong 10 times or more

session	target	order	count
1	ğ	25	12
1	c	22	11
1	K	39	2
2	K	39	9
2	B	45	17
2	S	42	14
2	D	43	13

Table 46. Syllables and words written wrong 10 times or more

session	target	order	count
3	ala	72	14
3	ta	84	13
3	talat	87	10
3	et	81	10
3	ilet	95	10
4	Tatilini	114	12
4	taneli	108	10
7	önde	254	11
8	önde	254	10
9	Kiraz	326	18
9	az	314	11
9	çizme	339	10
11	ef	431	13

Table 47. Targets written with line violation 4 times or more

session	target	order	count
1	i	4	4
2	K	39	5
3	8	65	4
9	üç	330	4
9	Kiraz	326	4
9	çok	341	1
10	çok	341	3
10	çadır	345	4

4.3.11 Student AT

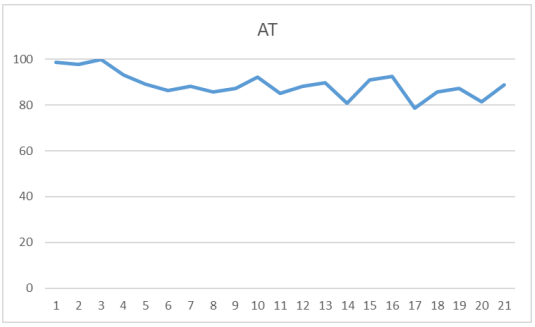

Figure 59. Percentages of on-task durations for each sessions

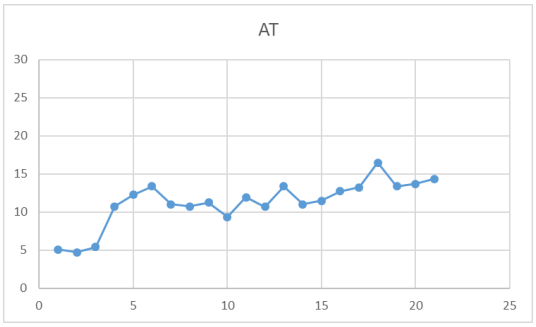

Figure 60. Writing speed (the number of written letters per minute for each sessions)

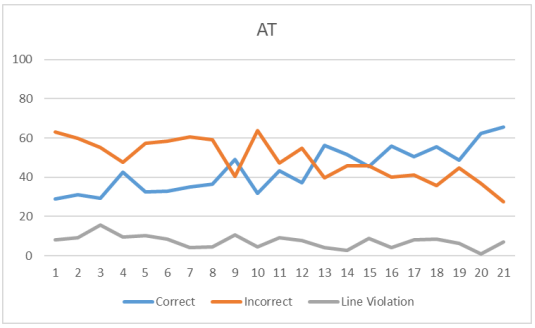

Figure 61. Percentages of correct-incorrect attempts and line violations for each sessions

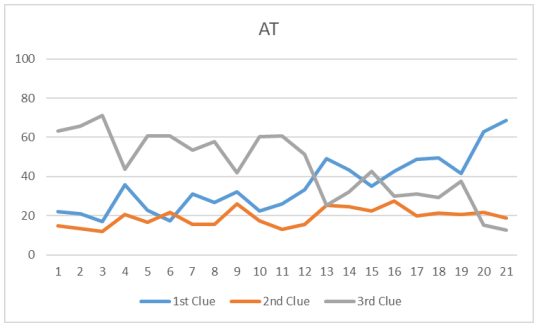

Figure 62. Percentages of three types of clues used by student for each sessions

On-task duration of AT ranged between 80% and 100% approximately for each session except for the 17th session. When the logs were analyzed, the 17th session covered 21 words including two of the most challenging letters, "ç" (6 words); "z" (15 words) (see Table 50). As can be seen in Figure 60, there was a continuous increase in the number of letters written per minute. Except for the 5th, the 10th, the 12nd, the 17th, and the 19th sessions, in all other sessions, while there was an increase in the number of correct attempts, there was a decrease in the number incorrect ones. In addition, a small

number of line violation observed in all sessions. The most challenging targets can be seen in Table 51. As can be seen in Figure 62, the number of third degree clues was high at the beginning and it decreased gradually. In addition, the most challenging letters and number for AT can be seen in Table 48 and Table 49 respectively.

Table 48. Letters written wrong 10 times or more

session	target	order	count
1	n	5	16
1	o	6	13
1	z	19	9
2	z	19	3
2	ç	20	23
2	R	36	16
2	T	32	14
2	j	28	11
2	v	26	11
2	K	39	2
3	K	39	40
3	S	42	12
3	F	56	12

Table 49. Numbers written wrong 10 times or more

session	target	order	count
3	8	65	8
4	8	65	5

Table 50. Syllables and words written wrong 10 times or more

session	target	order	count
4	alet	86	7
5	alet	86	8
5	talat	87	16
6	taneli	108	16
7	ona	121	14
7	Tatilini	114	12
8	rana	133	13
10	mut	156	13
10	tu	158	12
10	otur	164	5
11	otur	164	13
10	armut	160-165	9
11	armut	160-165	5
12	atını	180	14
12	tıl	181	12
13	asa	210	11
14	deve	243	3
15	deve	243	8
15	ör	247	17
19	horoz	403	9
20	horoz	403	3
20	iğne	413	11

Table 51. Targets written with line violation 4 times or more

session	target	order	count
1	l	1	4
2	T	32	6
2	ç	20	4
3	K	39	7
3	G	50	16
3	8	65	1
4	8	65	5
5	in	99	7
6	taneli	108	4
11	ok	167	5
15	Öner	251	4
21	jan	452	5

4.3.12 Most common mistakes of the students with dysgraphia

Table 52. The most common letters written wrong

order	target	n
22	c	7
6	o	6
15	ö	6
39	K	6
20	ç	5
28	j	5
3	t	5
32	T	5
56	F	5
2	a	4
4	i	4
18	ş	4

Table 53. The most common digits written wrong

order	target	n
65	8	3
66	9	3

Table 54. The most common syllables and words written wrong

order	target	n
160-165	armut	8
87	talat	8
114	Tatilini	8
81	et	5
95	ilet	5
249	öne	5
108	taneli	5
254	önde	4
133	rana	4
300	taşı	4
330	üç	4

Table 55. The most common targets written with line violation

order	target	n
20	ç	6
65	8	6
66	9	5
30	L	4
330	üç	4
1	l	3
50	G	3
57	J	3
38	U	3
41	Y	3

As will be seen from the table 52, 53, 54, and 55, there were some common learning objects that students had difficulties. A major reason for the common difficulties of students in these learning objects is that their writing is already difficult for all students.

4.3.13 Summary of Effectiveness Findings

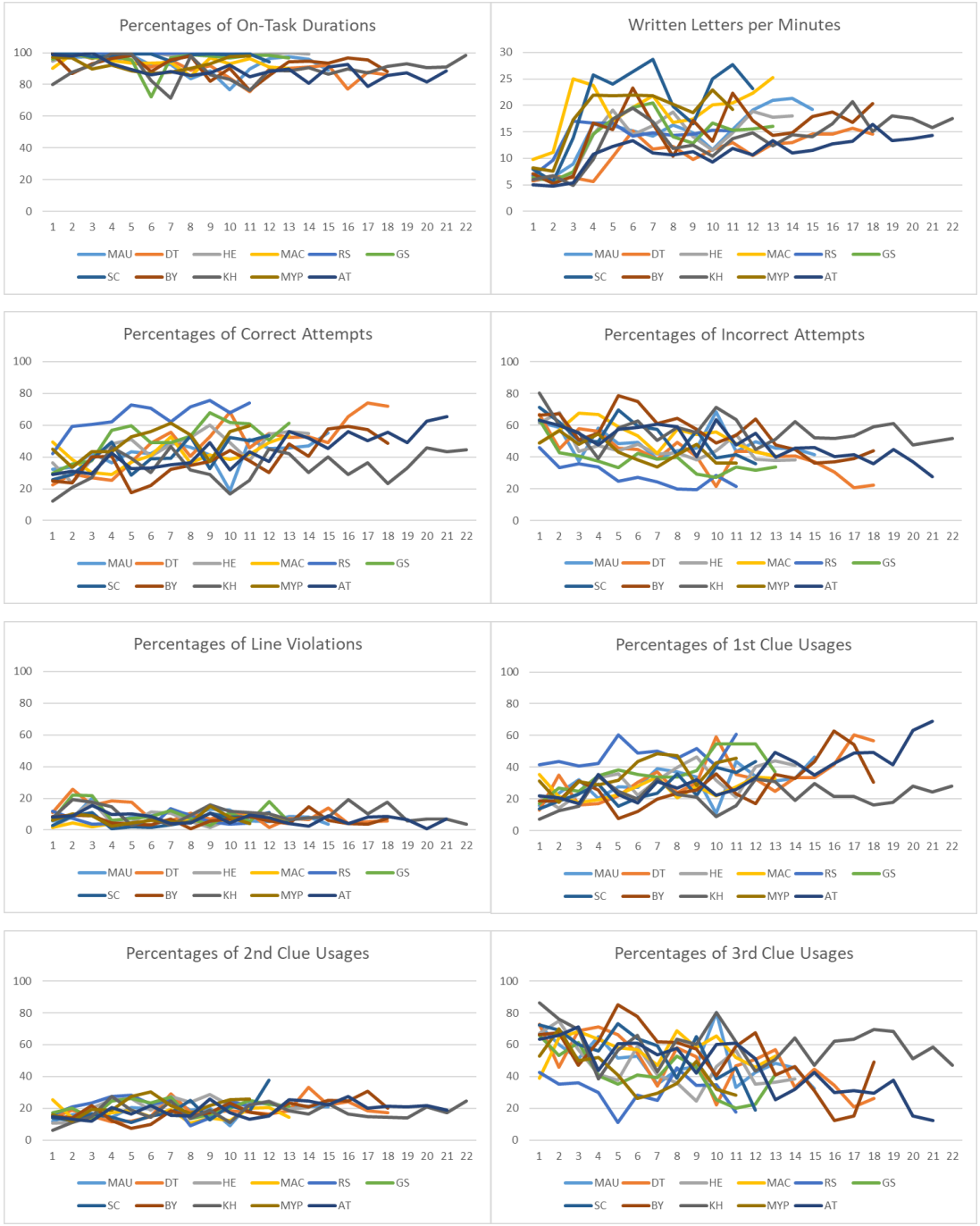

Figure 63. Students' percentages of on-task behavior, writing speed, percentages of correct- incorrect attempts and line violations, and percentages of three types of clues (the first, the second and the third clue)

In Figure 63, students' percentages of on-task behavior, writing speed, percentages of correct- incorrect attempts and line violations, and percentages of three types of clues (the first, the second and the third clue) were presented respectively. Findings of the study showed that students' percentages of on-task durations were in a range of 80% and 100% approximately. In other words, they studied at least 36 minutes of a session which was 45 minutes. Moreover, the writing speed of all students increased session by session. Besides, the number of correct attempts of the students were increased and the number of incorrect attempts and line violations decreased session by session. In addition, the frequency of the third-degree clues tends to decrease session by session while the other clue types seem to be at the same level or tend to increase.

4.3.14 Relationship between writing speeds and correct attempts

A correlation test was employed in order to reveal if there is a relationship between the students' writing speeds and the number of correct attempts. Table 56 shows that, except for two of them, there are significant correlations between writing speeds and correct attempts.

Table 56. Correlations between writing speeds and correct attempts

	MAU	DT	HE	MAC	RS	GS	SC	BY	KH	MYP	AT
p	.02	.00	.00	.83	.01	.02	.04	.30	.01	.04	.00
r	0.59	0.81	0.78	-	0.70	0.65	0.60	-	0.52	0.64	0.73

4.4 Research Question 3: What are the views of special education teachers about mobile writing application after the utilization of mobile writing application?

A semi-structured interview protocol was conducted after the experiment with special education teachers for in-depth analysis. Special education teachers' views after the experiment were examined as following five themes: 1) perceived ease of use, 2) perceived usefulness, 3) perceived enjoyment, 4) aspects need to be improved, and 5) future use.

4.4.1 Perceived ease of use

All interviewed teachers (n=7) perceived mobile writing application as easy to use.

One of them (ST1) stated that students were familiar with tablet:

> *"All of them were very familiar with the tablet already. In fact, initially it was something children were not familiar with it [stylus pen]. The children had difficulty due to the fact that they did not use digital pen before. However, it did not take long and they get used to it in 2 minutes. I think it was nice to use."*

Similarly, another teacher (ST2) claimed that even a small child can use it easily:

> *"It is not difficult. It is an applicable project to the students. Even so students can use it in the spring term of the first grade."*

One teacher (ST3) stated that writing on a screen is easier than writing on a paper:

> *"Actually, it is easy to use for students. So writing to tablet is better instead of writing a paper. Moreover, the screen is [slippery]."*

Another teacher (ST6) thought that the application ensures the ease of use with feedback and reinforcements:

> *"Children were guided by the application already. For example, it gave a feedback when (s)he made a mistake or it rewarded when (s)he earned. "*

Most of teachers (n=4) found the stylus pen easy to use, three of them had some concerns. For example, one of them (ST2) stressed:

> *"I think the pen sometimes got stuck, did not it? Did it prevent children to study serially? But if it can be improved, a pen which is more slippery and easier one, children will be more successful."*

ST3 discussed that there can be problems according to the pen holding positions:

> *"Children must be able to begin [writing] process when (s)he puts pen [on the screen]. Children should not be bothered: 'let's grip pen this way, let's grip pen that way'"*

ST5 suggested a pen with a small tip:

> *"I think, the thing on the tip of the pen is not very practical. Being transparent increases the practicability, it is an advantage. But we can try it with other pens have a little pointed tip."*

Theme: 1) Perceived ease of use
Teachers' Views

- Mobile application was easy to use because:
  - The students were familiar with tablet.
  - Even a child who was in 1st grade and second term can use it easily.
  - Writing on a screen is easier than writing on a paper because the screen is more slippery.
- Students have never used a stylus pen however; they got used to use it easily in a short time.
- Some of teachers had some concerns about use of stylus pen:
  - Pen holding positions should not be a problem for students.
  - A pen with a small tip was suggested.

4.4.2 Perceived usefulness

All interviewed teachers (n=7) perceived mobile writing application as useful for students with dysgraphia from different perspectives.

Two of teachers (ST1 and ST3) claimed that mobile writing application makes writing more interesting than pencil and paper. Therefore, mobile applications are more useful. For instance, ST1 expressed:

> *"I found it very good. It was interesting for children because of using a different thing instead of paper-pencil."*

In the same way, ST3 stated:

> *"They used to get bored before. Now, they ask to write [on the tablet] themselves."*

Moreover, teachers pointed out other useful aspects of mobile writing application. ST1 deduced in a traditional writing class, teachers cannot be aware of mistakes in writing direction:

"For example, children were needed to return at some point while they were writing "a". I did not notice it, since I did not know this issue much. In fact, the cause of difficulty while writing was that child cannot write the letter accurately. However, your application gave feedback when child did not return from the half of the letter. And (s)he had to do it again."

Correspondingly, ST3 believed that learning writing direction leads accurate writing:

"At least, I think, they learned the writing directions of letters. They can use [write] them correctly."

ST1 addressed usefulness from the perspective not only allowing monitor but also improving writing skills:

"I think, it is very nice for monitoring children, for monitoring where their mistakes are. Thereafter, for example, now I am looking at my students' writing, they have improved more. Even, I thought it'd be much better if students write their assignments in [application] [she laughs]."

ST1 compared the application and the notebook in terms of the number of pages:

"We have to give some students activities dozens of pages. It seems long to him/her but in the tablet [application] does not seem long. Therefore, it is good."

All of the teachers believed that mobile writing application was useful for improving writing skills of students. ST3 believed that the application improved writing skills of students more accurately:

"I think that the students develop their writing [skills] because they usually write without knowing. But this application shows them how to write beforehand, when children make a mistake, [mobile application] shows the mistake to them so I think it is useful."

ST3 thought using visual in the application made learning permanent:

"Besides, when [writing] is on the tablet, it is more permanent for the child. Well, icons are very important for us. Visualization is very important. If there is visualization, it will always be in the child's mind."

ST5 claimed that the writing application ensures concentration more than paper-pencil sessions:

"Considering they [children] could study for a long time, they motivated. Normally it would not."

ST6 stated that visual and audio elements facilitated learning to write:

"So, since the child was presented both auditory and visual stimulus, both writing and learning were easier. I think it is a good application."

Moreover, ST2 emphasized that the application facilitates teacher's teaching activity:

"I would definitely use this application. Because, instead of holding children's hand and dealing with writing, using tablet [is easier]. The application tells [how to write]."

ST5 stated that the application was great with its hierarchical clue system and it was also inspiring for special education field:

"I think it is a good thing, because at first [children] see [the learning objective] clearly. Children were trying to do it, if they could not, [the application] gave them hierarchical clues."

Likewise, ST7 acknowledged the application was effective because of its feedback system:

"Because applications which tell mistakes like 'you overflowed the bottom line, you overflowed the top line etc.' to the [students] especially are more effective" and she added:

"So, as I said, making the lessons enjoyable, concretizing, correcting the mistake of the students [were advantages]."

Theme: 2) Perceived usefulness

Teachers' Views

- Mobile writing application was useful because:
    - It makes writing more interesting than pencil and paper.
    - In a traditional writing class, teachers cannot be aware of mistakes in writing direction and learning writing direction leads to accurate writing.
    - It allows monitoring.
    - It improves writing skills.
    - Unlike traditional writing activities, there is no too many pages in mobile writing application.
    - It allows students to write more accurately.
    - Using visual in the application made learning permanent.
    - It ensures concentration more than paper-pencil sessions.
    - Visual and audio elements facilitated learning to write.
    - It facilitates teacher's teaching activity.
    - The way how hierarchical clue system used is perfect.
    - It has an effective feedback system.

4.4.3 Perceived enjoyment

All participants perceived mobile writing application as enjoyable for students with dysgraphia except for ST5. For example, ST1 stated:

> *"In fact, many of them had fun. They had a stress like that they should beat other children. But in fact they enjoyed when they were away from stress themselves."*

Two of special education (ST3 and ST6) teachers claimed that mobile writing application was enjoyable such that students came to special education center just because of this application. For example, they stated (ST6 and ST7 respectively):

> *"We witnessed children came to school to use this application because they had much fun..."*

> *"They had fun so that they never complained. They did not say that we were bored or something. They might even come for application. "*

Similarly, ST7 stated:

> *"We could see that they were more willing to come, it sounded fun. They were smiling most of time" and added:*

"For example, if you apply it at schools, I think you would ensure more participation."

ST6 and ST7 claimed that this application made writing enjoyable for students. For example, ST6 stressed:

"Sometimes, writing can be boring for children. However, we make it [writing] with gamification. Besides, using both visuals and sounds are fun for children. "

ST1 and ST3 put forward the application was like a game. For example, ST1 stated:

"It does not seem like a course; it is seen by everyone as a game. Child finished all the words [in the application], who has difficulties with writing when I gave a paper to write him/her."

Similarly, ST3 thought:

"It was usually presented as a game; I think they loved it [writing]"

ST5 did not perceive mobile writing application as enjoyable because of the fact that games did not come after every accomplished goal:

"Since there is a teacher in traditional setting, s(he) can make other activities. However, it is not like that in the tablet. Well, can it be? Absolutely, doable… I think it would be much more fun after children write "a" sound correctly, a game presents as a reward from the tablet automatically."

Theme: 3) Perceived enjoyment
Teachers' Views

- Mobile writing application was enjoyable because:
  - Students had fun.
  - Students came to special education center just because of this application.
  - Application made writing enjoyable for students.
  - It is like a game.
  - It is perfectly appropriate for students with dysgraphia.

4.4.4 Aspects need to be improved

ST4, ST5, and S6 claimed that there is no need to revision/modification for any part of the writing application. On the other hand, some of teachers had some suggestions. As mentioned previously ST2 and ST3 suggested improving the use of pen.

ST1 recommended that there should be a line on the animation screen:

> *"I said one thing. There was a text in the animation part [clue]. The letter was just on a blank space. If it was on a line like in the beautiful writing pad, they would have seen the [line] spacing."*

ST7 suggested that the application should be more precise:

> *"[The application] accepted some letter as correct when [students] wrote similar letter. For instance, when student wrote 'k' instead of 'h' it [the application] accepted it as correct."*

ST3 stated that students should be presented awards at every stage of the application as a reinforcement:

> *"Children in general, you know, want a reward at the end. I think there can be a reward for every accomplished mission."*

Theme: 4) Aspects need to be improved
Teachers' Views

- The use of pen should be improved.
- There should be a line on the animation screen.
- Application should be more precise.
- Students should be presented awards at every stage of the application as a reinforcement.

4.4.5 Future use

All participants (n=7) wanted to use mobile application for educational purpose.

ST1, ST3, ST5, and ST7 underlined that the educational mobile application gets children's attention. For example, ST7 stated:

"Now, when a teacher lectured only, it is boring. They [the applications] prevent boredom and get children's attention."

Besides ST5 deduced that getting children attention can lead more focus on:

"All technological tools are interesting for children. Children can be more concentrated because of that."

ST7 stated that educational applications provide the most updated information:

"Also, some of the information updated. They [educational applications] are more accurate."

In addition, teachers (ST1, ST3, and ST5) emphasized, we are in the era of technology therefore, and this situation has necessitated us to take advantage of mobile educational applications. For example, ST1 stressed:

"It does not work with paper-pencil because we live in technology age. We have to move on mobile applications compulsorily."

ST1 emphasized that mobile applications provide proper and easy monitoring of work:

"At first, monitoring is very easy. I have to have a lot of paper here; I have to group them according to students. There is not anything like that in the mobile applications. I know how much progress he/she made."

ST3, ST5, and ST6 emphasized the importance of using visuals. For example, ST3 stated:

"Paper are always black and white. You know the photocopies. Usually colored stuff attracts the attention of children."

Similarly, ST6 emphasized the role of visualization in learning:

"Visualization always facilitates learning more. Therefore, the child sees and writes at the same time. Many senses of her/him work at a time."

ST4 claimed that educational applications reduce the mistakes of children with immediate feedback:

"Mobile application reduces mistakes a little. Children can see their mistakes easier and earlier. It would be nice in terms of good writing."

ST3 thought that educational applications can help teachers:

"They are practical and useful for teachers."

Theme: 5) Future use
Teachers' Views

- All teachers want to use mobile application for educational purpose because:
    - It gets children's attention which leads them to focus more.
    - Educational applications provide the most updated information.
    - The use of mobile applications could bring many advantages in the era of technology.
    - It provides proper and easy monitoring of work.
    - Using visuals is very important for learning.
    - The educational applications reduce the mistakes of children with immediate feedback.
    - The educational applications can help teachers in many ways.

4.5 Summary of the Results

In this study, the result were presented in terms of research questions. Firstly, the findings of special education experts', classroom education experts', educational technology experts', classroom education experts' and the classroom education teacher's views about application before the experiment were presented in terms of perceived ease of use, perceived usefulness, perceived enjoyment, educational content, visual design, multimedia use and technical features. Experts' views before the quasi-experimental design were very positive. The aspects need to be improved were modified before the experiment.

Secondly, the findings of experiment and log were given. The mobile writing application contributed to acquire writing skills (letter, spells, and words) for students with dysgraphia. Students' percentages of on-task durations were in a range of 80% and 100%. When the writing speed of students session by session were examined, there was an increase in all of them. The correct attempts of the students were increased session by session and the number of incorrect attempts decreased. The line violation of the students tends to decrease session by session. The frequency of the third-degree

clue tends to decrease the session by session while the other clue types seem to be at the same level or tend to increase.

Finally, findings of the interview with special education teachers after the experiment for in-depth analysis of the application and procedure were presented. Special education teachers' views were positive about mobile writing application.

CHAPTER 5

DISCUSSION AND CONCLUSION

This chapter presents discussion of research findings in this study, conclusion, some recommendations for future research, and limitations. This study had three main research questions and one sub-question.

The main purpose of this dissertation is to examine the effectiveness of a mobile writing application for students with dysgraphia and to determine whether there is an improvement of writing skills of the students after using this application. A mobile writing application was developed for this purpose after taking the views of experts into consideration. This study examined whether mobile writing application contribute to acquisition of writing skills (writing letters, numbers, syllables, and words) for students with dysgraphia. Furthermore, on-task behavior, writing speed, correct-incorrect attempts, line violations and clues were examined in the context of effectiveness. Finally, after the experiment, special education teachers' views, whose students participated in the study, were explored. This chapter discussed the findings of the study in the light of the research questions.

5.1 The Views of Experts about Mobile Writing Application before the Utilization of the Mobile Writing Application

Special education experts, educational technology experts, classroom education experts, and the classroom education teacher found application appropriate for target audience to acquire writing skills. Discussion was made in terms of "perceived ease of use, perceived usefulness, perceived enjoyment, educational content, multimedia use, and technical features".

"Perceived Ease of Use" was determined as one of themes that was investigated to analyze the views of experts and the teacher before the utilization of the mobile writing application. All participants perceived mobile writing application as easy to use. This

was an important phase for the researcher before applying the application on the students. In line with this interpretation, Fernández-López et al. (2013) also highlighted the importance of the ease of use as one of the several principles integrating a technology into special education. Similar to teachers' views, Kagohara et al. (2013) mentioned that uses of these tablet devices are easy. In this study, the researcher received positive remarks with regards to the application however, there were some criticisms in relation with the use of stylus pen. The reason for this could be explained with the difference in use and shape when compared the normal pen. This becomes obvious since the tip of the stylus pen is quite different in use. This concern has been revealed in the related scholarship. Annett, Anderson, Bischof, and Gupta (2014), and Helps and Helps (2016) categorized stylus pen as "active and passive" based on the use in capacitive touchscreens. The prices of active stylus pens are higher than the passive ones (Annett et al., 2014; Tanyag & Atienza, 2015). Therefore, the widespread use of stylus pen seems to be limited and constrained in near future due to economic costs. In addition, not all active stylus pen are compatible with all brands/tablet models (Helps & Helps, 2016; Tanyag & Atienza, 2015).

The tips of passive stylus pens vary. Most of them are made from rubber. They are soft and thick-tip. None of them is able to show the exact written place (Helps & Helps, 2016). This is problematic especially for students who start to learn writing. Another type of passive stylus pens are those with hard and transparent tips (Helps & Helps, 2016). This allows the student to see where (s)he writes exactly. In the current study, this kind of pen was selected since it was appropriate and inexpensive. In addition to the "perceived ease of use", "perceived usefulness" was also investigated in the pre-experimentation process.

"Perceived Usefulness" serves as one of the means that leads teachers and students to get involved in the learning process while using a mobile application. The researcher wanted to get the views of experts and the teacher before applying it on the students from the basis of "perceived usefulness". Their responses showed that all of them agreed on the usefulness of the application. Their views showed that such applications are needed in learning to write as well as creating a better learning setting for both students and teachers. The results also showed that students will be able to study on

their own and will be able to practice more. In line with this idea, Miller (2002) revealed that students with learning disabilities should make practice more than their normally developing peers. Similarly, Fernández-López et al. (2013) mentioned that mobile devices enable students to learn independently and ubiquitously.

"Perceived Enjoyment" serves as the basis of all the learning processes. When asked about the ways in which experts and the teacher found the application enjoyable, all the participants gave similar responses that highlight the strength of the application as interesting. In this context, it can be inferred that the application is interesting and enjoyful for the students. Their responses indicated the ways in which students' motivation could be higher when dealing with such tasks. This view aligns with the idea put forward by Fernández-López et al. (2013) who asserted that students are more willing and able to study longer with such educational activities. Therefore, these views support the idea that the more students get involved and enjoyed the process the more they learn it easily.

The researcher also investigated the views of experts and the teacher with regards to the *"Educational Content"* used in the pre-experimental phase. All participants accepted that educational content was appropriate. Thus, it can be said that the selected content of application was in accordance with the current curriculum. In addition, the scope of the application was sufficient to acquire writing skills. Classroom experts and the teacher mostly agreed on the size of the writing area. The reason is that students with dysgraphia have learning difficulties and they are in the process of learning to write. Thus, experts noted that it would be easier for the students to write if the line spacing was larger than normal. Considering this fact, larger spacing was used than the normal spacing in this study. Similarly, Harley et al. (2013) underlined the importance of expanded line spacing in order to make let students read the text easily. In line with this, Li-Tsang et al. (2013) used triple-line spacing for students with specific learning disability (handwriting problem). Likewise, Romani, Tsouknida, di Betta, and Olson (2011) used double-line spacing for students with dysgraphia. All these studies emphasize the possible impact of larger line spacing in literacy.

The researcher also investigated the views of experts and the teacher with regards to *"Visual Design"* in the pre-experimental phase. All the participants found the visual design of the application as appropriate. From this point of view, it can be said that the visual design features are appropriate in the study. The colors, which were age-appropriate, were included to increase the motivation of the students. Yılmaz (2008) stated that colors should be used correctly because it affects perception for students with intellectual disabilities. In addition, in the current study interface design was simple and not distractive. In line with this, Yılmaz (2008) emphasized that especially for students with intellectual disabilities, the interfaces must be in the simplicity that will not distract the student. Besides, too many visual elements were not added for preventing distraction. Similarly, Yılmaz (2008) revealed that irrelevant items should not be used. Also, visuals should be designed in a way that is appropriate and effective to the subject for students with intellectual disabilities. As a matter of fact, none of the students had any problems arising from the visual design.

In addition to *"Visual Design", "Multimedia Use"* was determined as one of themes that was analyzed from the views of experts and the teacher before the utilization of the mobile writing application. All the participants accepted that multimedia use was appropriate in this study. Thus, it can be inferred from the results that the multimedia used in the application aligns with the content as well as meeting the expectations of the target audience. Two types of animations were used in the application; former aims at making the application enjoyable (the arrow animations for scores) and the latter, facilitating students' learning (second-degree clue). The various use of animations and the positive influence seen on the learning outcomes was also mentioned in the study of Azimi and Mousavipour (2014). Apart from the animations, the background music was also found to be appropriate by the experts. Similarly, Ke and Abras (2013) emphasized that the background music and cartoon characters were grabbed students' attention. In line with this, Takacs, Swart, and Bus (2015) underlined that animations, background music and sound effects which are coherent with the content can facilitate understanding of children with language delay.

The last theme analyzed in the pre experimentation process was related with the "*Technical Features"* of the mobile application. In this study, two issues were

analyzed the areas of consideration by the experts. The first issue was as to whether it was easy to install. Although their responses fall into the category that represents the ease of use in the downloading process, there were a few remarks that recommend putting more information for the users about the phases of the download. The researcher informed them that this constraint will be overcome after the application was put on the markets. The second issue was about error-freeness. Experts agreed on the error-freeness of the application. However, they also warned the researcher about the potential risks that could emerge in a long time use in various users. In line with this, Bardhan Ullah, Ahmed, Rabbani, and Al Mamun (2016) emphasized that the software for autism should be error-free. Likewise, Baumgartner and Payr (1996) underlined that educational software should be error-free and user-friendly.

So far, the results obtained in the pre-experimentation phase showed that the mobile writing application developed in this study could ready to be used on the students with dysgraphia. After taking these views, the researcher investigated the effectiveness of the mobile writing application through pretest and posttest as mentioned in the remaining parts of this study.

5.2 Effectiveness of the Mobile Writing Application

Effectiveness of the mobile writing application was examined by means of pretest and posttest scores obtained from the students in addition to observation notes and log data. When the test results were examined, the posttest scores of the students were significantly higher than the pretest scores. In other words, the findings of this study showed that the mobile writing application contributed to acquire writing skills (letter, spells, and words) for students with dysgraphia. The analysis revealed that the mean of the ranks in favor of posttest was nearly double the mean of the ranks in favor of pretest. It was determined from the analysis that intervention had a positive impact on writing skills of students with dysgraphia. Considering the duration of the study (the student, who studied the most, studied 22 sessions and 16 hours), it can be said that the mobile writing application was very efficient to acquire writing skills for students with dysgraphia. All of the students participating in the study were the second grade and above. Acquiring writing skills in such a short time, which they could not learn at

school so far, addressed the efficiency of the mobile writing application. Şahin (2012) supports this finding with the duration of learning to write as a one year even in normally developing students. In this context, the application appears to be helpful for the students with dysgraphia. This is important when there has been scarcity of empirical evidence in the related scholarship. There are only a few studies that highlight the ways in which writing skills could be developed for students with dysgraphia through the use of educational technology. In a study that investigates the effectiveness of an educational multimedia in dictation for second grade students with dysgraphia, Azimi and Mousavipour (2014) compared the use of traditional method and multimedia dictation. Based on the results of the mentioned study, a significant difference was found in favor of the experimental group who had educational multimedia dictation. Similarly, Palluel-Germain et al. (2007) investigated the effectiveness of telemaque on handwriting fluency of 42 kindergarten students before transition to formal writing instruction. Their comparison with the use of traditional method and a visio-haptic interface (telemaque) showed that the students in experimental group were significantly better than the students in the traditional group. In addition, the authors concluded that this interface should be used for students with dysgraphia to enable improving their handwriting skills. Tanimoto et al. (2015) investigated the effectiveness of computerized and mobile devices based writing and reading instruction for between 4th and 9th grades students with specific learning disabilities. Computerized training (visual motion cue and writing activities on a blank monitor screen) was administered to group A consisting of 21 students and an iPad training (sequential, number, arrow cues and writing activities between lines on iPad) was given to group B consisting of 11 students. The findings of the research indicated that group B was significantly more successful than group A. It could be interpreted from the related scholarship that there has been an increasing need to develop alternative mobile applications that focus on developing writing skills. This is also important in the cases of students with dysgraphia. Therefore, the results obtained in this study is expected to provide insights for the instructional designers in a way to open alternative learning paths for the students with dysgraphia since pretest and posttest scores highlight the fact that the application is effective. The application also shortens the time span spent on the process and the application was found to be

efficient. In addition to pretest and posttest analysis, log data, and the observation data showed the following mentioned areas of effectiveness in the mobile application. Following dimensions were analyzed in these notes:

5.2.1 On-task behavior

Students' percentages of on-task durations were in a range of 80% and 100%. In other words, they studied at least 36 minutes of a session which was 45 minutes. Godwin et al. (2016) inferred from the related literature that even for normally developing children' on-task behavior percentages are 50%-90%. It can be said that the application was successful at ensuring students' study without interruption although they were very different individuals. Moreover, it is considered that mobile writing application affected students' study habits positively. Similarly, since new technologies provides students with more customizable options, students can stay on-task more (O'Connell, Freed & Rothberg, 2010).

However, the findings of this study revealed that there were significant decreases in the percentage of on-tasks behavior of some students at some sessions. Related literature showed that effective designs, easy-to-implement educational applications are not easy to develop for increasing on-task behavior of students (Godwin et al., 2016). This is mostly because students had difficulty in writing the learning object(s) in those sessions. That is to say, because of having difficulties and making many mistakes made students bored in those sessions and they wanted to study less than other sessions. Correspondingly, Chung and Patel (2015) emphasized that the difficulties that the student with dysgraphia experienced in writing, affected staying on-task negatively. Similarly, Gambrell, Wilson, and Gantt (1981) revealed that on-task behavior duration of good readers was 11% more than poor readers'.

Furthermore, as it could be seen in the related literature, students with hyperactivity have difficulties in keeping on-task behavior (DuPaul, Ervin, Hook, & McGoey, 1998; DuPaul & Weyandt, 2006; VandenBerg, 2001). DuPaul et al. (1998) underlined that students with hyperactivity can be off-task above the average percentage in a traditional classroom setting. Moreover, DuPaul and Weyandt (2006) underlined that

students with hyperactivity have a tendency to escape writing activities or written assignments. In line with these, VandenBerg (2001) emphasized that children with hyperactivity avoid fine motor tasks such as writing. Besides, it is compelling to completing a task for them. In the current study, two students (MAU and KH) who participated in the experiment were also diagnosed with hyperactivity as well as learning difficulties and they were using medicines. The mobile writing application has been successful in keeping these students on-task.

Additionally, mobile educational applications have a promising potential in special education. Students with specific learning disabilities have motivational problems (Flanagan, Ortiz, Alfonso, & Dynda, 2006; Friend, 2005; Lyon, 1996; McKinney, 1984). Mobile educational applications can increase students' motivation with their educational scenarios (Bae, Lim & Lee, 2005; Peng et al., 2009; Ruchter, Klar, & Geiger, 2010; Traxler, 2010). Accordingly, they may ensure to stay on-task of students. This study was observed to be successful to enable students with dysgraphia and several of hyperactivity to spend a more focused time on the application as well as cultivating their study habits in a positive way. The researcher was aware of the fact that each one of these 11 students had unique characteristics and learning disability conditions. Their common characteristics were to face with the problems related with dysgraphia. The application used in this study appears to meet the needs of these students in a way to encourage them to continue writing. The other dimension that was explored in the study was writing speed and the results are as follows.

5.2.2 Writing speed

Another variable is the writing speed regarding the quality of handwriting (Şahin, 2012). The findings of the study indicated that the writing speed of all students increased session by session. Considering slow writing speed as a problem of students with dysgraphia, the results obtained in this study could be seen as a noteworthy improvement. Increasing the writing speed often raises a suspicion whether they write correctly or not. This study shows that students do not make mistakes when they write fast; on the contrary, they start to write quickly and correctly. Correspondingly,

Kadıoğlu (2012) found a significant positive relationship between writing skills and speed.

Literature reveals that writing requires skills rather than knowledge and skills are acquired by practice (Akyol, 2005; MONE, 2005). A well-designed instruction and a sufficient amount of the practice can provide the automation of the skill. The result of automation is not only correct writing but also writing faster (Jones & Christensen, 1999). It could be said as a results of the log data that the current application contributes to acquire handwriting skills and teaches the students to write fast.

Similarly, Smits-Engelsman and Van Galen (1997) explored that the writing speed of children increased in a longitudinal study, applied on primary school students with dysgraphia, in which a computer software with a digitizer tablet and a special pen with a pressure sensing device was used. Correspondingly, Chang and Yu (2014) revealed that there was a significant difference among computer-assisted group, sensory motor training group and a control group. Computer-assisted group showed a promising improvement in writing speed and fluency.

The results obtained from the current study seems to aligns with the result of the related literature that highlight the change observed in the writing speed as well as maintaining accuracy. This may be important in classroom settings where there are students with different characteristics as well as various forms of specific learning disabilities. In the following title, correct and incorrect attempts collected in log data seems to align with the results obtained in the previous sections.

5.2.3 Correct and incorrect attempts

For a legible writing, it is important to write the letters and the words correctly (Kodan, 2016). Correspondingly, Yıldız (2013) suggested that in order to acquire legible writing skills to students with dysgraphia, firstly it is necessary to ensure that the letters are produced correctly. The main aim of mobile writing application is to acquire accurate writing. Findings of the current study showed that the correct attempts of the students were increased and the number of incorrect attempts decreased session by session. Likewise, Smits-Engelsman and Van Galen (1997) explored that the incorrect

attempts in children' writings were decreased in their longitudinal study which was applied 16 primary school students with dysgraphia. They used a computer software with a digitizer tablet and a special pen with a pressure sensing device. In the current study, mobile writing application assumes the attempt is wrong if the drawing style is not correct even if the appearance of the letter is correct. In order to achieve this, gesture recognition algorithms were used instead of handwriting recognition algorithms. Handwriting recognition algorithms do not pay attention to the drawing style. This dimension is expected to contribute to increase students' involvement in the classrooms since the student is expected to use hand movements in the real life context. In addition to this, students may also feel motivated to write better in an accurate form. Apart from this, the mobile writing application also serves to overcome the problem of line violation.

5.2.4 Line violation

One of the important points in writing is following the line. The appearance of the letters and the shape of the drawing may be correct, but if the writing does not advance along a single line, this is regarded as an unsuccessful writing sample. In a study on primary school teachers conducted by Şahin (2012), line violation was indicated as one of the main problems in writing even for normally developing children. Yıldız's (2013) action research study with a student with dysgraphia revealed that even when the student asked to retrace the letters, the student had difficulties to follow the line.

One of the aims of the mobile writing application is to push students to write along the line. In this context, when the student exceeds the amount of line 5 pixels, writing of the student is not accepted by the application even if the student writes correctly. And also, the student is asked to be more careful by giving feedback on which line is over. Findings of the study revealed that students had difficulty following the line in letters with dots (ş and ç etc.) and letters with descenders (y, g, and ğ etc.). Correspondingly, Yıldız (2013) expressed that the student with dysgraphia made line violation in (g, ğ, p, s, and ş) letters. However, the researcher observed in the current study that the line violation of the students tends to decrease session by session. It could be thought that students can learn to write without line violation by doing more practice while enabling

them to write accurately. So far, effectiveness of the mobile writing application was analyzed from the dimensions of on-task behavior, writing speed, correct-incorrect attempts and line violation. Although all these were given in separate titles, each of them feeds the other in a way to enable students to focus on writing with better accuracy. The use of *"Clues"* also serves as one of the basis of the application not only in terms of maintaining effectiveness of the application but also supporting the students through the use of effective teaching strategies. As it could be seen in the remaining title, clues opened learning way for the students with dysgraphia.

5.2.5 Clues

Three levels of clues are exhibited by the application. The first clue is showing writing direction (s) of the letter/number/syllabi/words by arrows. The first clue type is the least helpful clue. The second clue is showing how to write the letter/number/syllabi/words by animation. In addition, the third clue is the dotted version of the letter/number/syllabi/words with second clue. Students retrace these points, drew a letter or word. The third degree clue is the most helpful and also it leads the student to think least. The findings of the study showed that the frequency of the third-degree clues tends to decrease session by session while the other clue types seem to be at the same level or tend to increase. Considering sessions progress, it can be inferred that students learn to write more correctly and they do not need a third degree clue. Thus, first and second clues are sufficient to provide the correct writing. Similarly, Tanimoto et al. (2015) revealed that more improvement was seen in the group with more clues (sequential, number, arrow cues and writing activities between lines on iPad).

Students with specific learning disabilities exhibit a tendency to depend on other people during their learning (MacInnis & Hemming, 1995). With these clues mobile writing application support students to learn independently. That is to say, students with dysgraphia can acquire writing skills with minimum supervision. Similarly, Fernández-López et al. (2013) mentioned that mobile devices based learning allows students to learn independently and ubiquitously.

In addition, mobile devices enable the students to study at their own pace (Evans, 2008; Kagohara et al., 2013) and in various places (Evans, 2008). These are other advantages of mobile devices for studying individually and independent from time and space.

Related literature and the results of the study all highlight the impact of using clues in the teaching process in the use of mobile applications. Log data results showed the ways in which students were allowed to work independently with their own pace by using the clues given by the application.

The effectiveness of the mobile application was investigated from the below mentioned dimension so far. However, the researcher was aware of the fact that there may be some constraints encountered due to the system. The following title reveals the results taken from the log data with regards to the common mistakes done by the students with dysgraphia.

5.2.6 Most common mistakes of the students with dysgraphia

In this study, the major reason for the common difficulties which students faced in these learning objects is that their writing is already difficult for all students. Letters in which students had difficulty to write seems to be in parallel with the problems observed in the related literature. Correspondingly, two studies revealed that normally developing students had difficulties in writing letter "F" (Demirkol, 2012; Şahin, 2012), letter "T" (Şahin, 2012) and letter "a" (Şahin, 2012). In addition, Bektaş (2007), Arslan (2012) and Demirkol (2012) found that students had difficulty with letter "ş". It is obvious that there is not any problem caused by mobile writing application or stylus pen. It can be seen that they were mostly letters with descenders and letters with dots or words containing these letters considering the most common learning object(s) which students had difficulties. In addition, most of the students had difficulties in the correct writing of eight and nine digits and they could not write these digits between the correct lines.

5.3 The Views of Special Education Teachers about Mobile Writing Application after the Utilization of Mobile Writing Application

Views of special education teachers were collected after the experiment. Face to face interviews were conducted to get an in depth views of teachers about the mobile writing application from the basis of "perceived ease of use, perceived usefulness, perceived enjoyment, aspects need to be improved and future use". Their views seem to be positive most of the time though there were several constructive criticisms given during the conversations. The remaining section discusses these views.

Views of teachers about the *"Perceived Ease of Use"* showed that all of them found the use of the application easy. Similarly, Kagohara et al. (2013) mentioned that uses of these tablet devices are easy. In current study, special education teachers emphasized that students have already used tablets in their daily lives. Also, Kagohara et al. (2013) emphasized that tablets can be easily available. Students have not used stylus pen, however, they could adapt to it in a very short time. Even a teacher said that writing to a tablet with a stylus pen is easier than writing to a paper with a pencil. The reason is that the stylus pen does not encounter any friction force on the tablet surface; on the contrary, it can slip easily. However, in order to write on paper, it is necessary to apply force a little. Similarly, Tseng and Cermak (1993) mentioned that the applied force and good writing are directly proportional. However, teachers suggested that stylus pen's grip angle should not be a problem and palm rejection feature should be more effective.

Views of teachers about the "*Perceived Usefulness"* revealed that the application is useful for students with dysgraphia. In line with this, Arpacık (2014) revealed that special education teachers believed that the interactive board is very useful for students with intellectual disabilities. Likewise, Doğan (2015) revealed that teachers stated the usefulness of the technology to provide a better learning opportunity for students with intellectual disabilities. In line with this, in Eliçin's (2015) study teachers emphasized that the tablet application was very beneficial for students with autism.

In particular, they emphasized that the application had an important role in attracting students and increasing their motivation in current study. While they do not want to

write too much in traditional lessons, now they say that they want to write by using this application. Moreover, teachers said that they know writing of some letters wrong. Owing to the application, teachers can correct their mistakes and guide their students correctly. They expressed that since the application allows them to see where students make mistake; they have a chance to focus these mistakes more. They daily use worksheet and have to prepare and print out a new worksheet each time so they have to consume paper and keep them. However, owing to this application, they said that they would no longer have to deal with worksheets; they could get rid of both paper consumption and their archiving. In addition, they observed that since the application allows the students to study more, they can write more accurate and faster than the old times. They stated that students' writing skills improved more after the use of the application than the traditional practices of the 4-5 months period. As a result, teachers considered that the application is useful in terms of keeping the students motivated when they study and facilitate teacher's activities. Similarly, Fedora's (2015) study on teacher candidates showed that using tablet and dictation software for students with writing difficulties was helpful for teacher candidates in a way to help them be ready and confident for integrating these technologies in their future classrooms.

Views of teachers about the "*Perceived Enjoyment"* showed that all the participants found the application enjoyable for students with dysgraphia. They emphasized that if it was not enjoyable, they would not study at least 80% of the session. They even observed that they were more enthusiastic about their lessons. Since the application had an educational scenario and supported with visuals and audio elements, students did not see the application as a lesson so they did not get bored. One of the teachers stated that one of his students normally did not work more than 15 minutes but he was surprised to see that the student studied almost whole session time. Similarly, Eliçin (2015) revealed that teachers emphasized that students with autism were more interested in tablet application than the traditional lesson. In current study, only one teacher mentioned that traditional education could be more enjoyable than the application. In traditional educational settings, special education teachers can start a different activity when students are tired/bored of writing considering the situation of their students. In addition, they can give small breaks or play games. Nonetheless, the

application has not been developed to take the place of a teacher completely. On the contrary, it has been developed in order to support the teaching activities of the teacher and to allow the students to do practice much more on their own.

Views of teachers about the "*Aspects Need to be Improved*" about the stylus pen, application, and their interaction seems to be positive most of the time. However some of the teachers indicated that the stylus pen and the interaction with the tablet should be improved. One of them indicate the lack of using lines in the animations as a weakness and suggested the researcher that lines should also be incorporated within the animations. The researcher took this recommendation as a note and reported in the study for further studies. In addition, one of the teachers mentioned that the application accepted some letters as correct when students wrote similar letters. It is obvious that the writing movements of some letters are very similar. Sometimes it is inevitable that the application may detect a similar letter instead of correct one. Such problems can be encountered not only in gesture recognition algorithms but also in handwriting recognition algorithms. In order to overcome this problem, sensitivity can be increased. Furthermore, a teacher suggested that some virtual rewards should be offered and added to students' profile.

Views of teachers about the *"Future Use"* revealed that all of them are eager to use it in their courses with the belief that it will enrich their courses in terms of both instruction and interaction. This result seems to align with the study of teacher candidates in Fedora's research (2015), in which almost three-quarter of teacher candidates were determined to be willing to use such technologies in their future classrooms. In line with this, in Eliçin's (2015) study teachers emphasized that they want to use tablet applications for students with autism since they are useful. Similarly, in Gauvreau's (2015) study the teachers were willing to use the mobile technologies in their classes for children with autism.

Especially, special education teachers thought that the application can attract students' attention in this study. Thus, the students can concentrate and can focus on writing more. As mentioned before, students with specific learning disabilities have attention problems. Much effort has been exerted to gather attention towards the important

stimuli in the learning environment (Friend, 2005; McNamara, 2007). Computers and these kinds of devices can gather students' attention and help them to focus on the learning task. This is crucially important in the case of students with learning disabilities (Fernández-López et al., 2013). In a similar manner, it reduces attention problems arising from mainstream classes (Zhang, 2000). Likewise, the teachers emphasized that the tablet application could increase attention span of students with autism (Eliçin, 2015).

Since such kind of an application can be improved and updated easily, teachers thought that they can access the latest accurate information with the help the application. Teachers reported the advantages of the application as serving as a facilitator both for their students and for themselves. They noted the value of the application as an instrument, which enables them to get ready for their courses while reducing the preparation time spent on regular classroom activities. In addition to being a supportive instrument, the application also helps teacher to monitor their students' progress based on real data as well as diagnosing the mistakes and misconceptions students make during the learning process.

5.4 Conclusion

Writing is a vital role in both daily life and academic life. Students begin learning to write first years in school and then they spent all of their lifetime by writing. Writing serves as one of the primary skills that helps students to get involved in learning activities. It should also be noted that although writing is analyzed as one of the skills in this study, it is a skill that could be related with the academic achievement.

This study focused specifically on developing writing skills. The main purpose of the present study is to examine the effectiveness of a mobile writing application for students with dysgraphia and to determine whether there is an improvement on writing skills of the students after using this application. In current study, a writing application was developed for this purpose taking the views of educational technology, classroom education and special education experts into consideration. A pretest-posttest quasi-experimental design with 11 students with dysgraphia was employed in current study. In addition, data were collected from mobile writing application log and special

education teachers' views were taken after the experiment. Also, observation was administered in order to determine on-task behavior of the students who used tablet application. Finally, both quantitative and qualitative data were interpreted. To sum up, the results of this study revealed: 1) Experts' views before the quasi-experimental design were very positive. The aspects need to be improved were modified before the experiment. 2) The mobile writing application contributed to acquire writing skills (letter, spells, and words) for students with dysgraphia. 3) Students' percentages of on-task durations were in a range of 80% and 100%. When the writing speed of students session by session were examined, there was an increase in all of them. The correct attempts of the students were increased session by session and the number of incorrect attempts decreased. The line violation of the students tends to decrease session by session. The frequency of the third-degree clue tends to decrease the session by session while the other clue types seem to be at the same level or tend to increase. 4) Special education teachers' views were positive about mobile writing application.

The application was helpful not only to enable students to write but also help them to write in an accurate way, continuing along the line and legible by everyone. It is inevitable that students with dysgraphia, which is a specific learning disability. They may face the problem of never being able to write accurately and legibly if their teachers and parents do not give additional support. In a regular class setting, it is almost impossible to help these students due to the constraints with regards to classroom setting, atmosphere, number of students in a class, teacher competency, and such. These students need to be involved with other students while they are also in need of getting individual support from their teachers. This becomes extremely difficulty in crowded classrooms, and in most cases, these students seem to get lost and disappearing in the class. Furthermore, having difficulties lead these students to get bored easily with the tendency to avoid writing. This study is expected to bring an application as a way to take away the barriers encountered in the classrooms and problems experienced by teachers with the help of educational technology. This is because the application developed in this study is expected to allow students to study individually or with little supervision and attract students' attention by enriching the learning environments as well as increasing their motivation. As it is case in most of

the research and experimental studies, this application also has some limitations. However, in this study the focus on writing accurately and legibly is expected to bring a perspective for the scholars working in the fields of educational technology, special education and primary education. Therefore, this study is expected to bring unique insights for students with dysgraphia and present teachers and experts an alternative method that could be used in the classroom setting. However, above-mentioned positive improvements may be considered as a result of the novelty effect of mobile writing application. Based on the researcher's observation and log data, positive attitudes of students towards to mobile writing application seem to be at the same level throughout the process considering there were a number of sessions (for example, 22 sessions for student KH, 21 sessions for student AT or 18 sessions for student BY and student DT).

In conclusion, the mobile writing application was determined to be effective, efficient and useful. This was confirmed with the pretest and posttest scores, log data, and observation notes as well as the interviews conducted with the teachers and experts. In addition to having results, that highlights the effectiveness of the application, experts and teachers shared views and comments indicate their willingness to use the application in their prospective classrooms. This study is limited to providing empirical outcomes about mobile writing application in a way to help students with dysgraphia to write in a more accurate and legible way. The study could be developed in further studies by looking it from different angles, which are design, development and evaluation of the mobile writing applications. The finding of this study is expected to contribute to the development of students with dysgraphia and present them with better tools for learning. The application is also believed to have positive influence on the professional lives of teachers and special education experts. This study did not investigate teachers and special education experts' competencies with regards to the use of mobile application. However, there were times when teachers and experts underlined the importance of teacher in all these processes. Therefore, the teacher has still be seen as a mentor, who leads the student to learn in the digital learning environment. In further studies, the ways in which professional development opportunities of special education experts and teachers could be developed from an

interdisciplinary perspective of special education, educational technology, and primary education.

5.5 Suggestions for future research

Results of this study revealed views of experts about mobile writing application, effectiveness on acquisition of writing skills (writing letters, numbers, syllables, and words) for students with dysgraphia, on-task behavior, writing speed, correct-incorrect attempts, line violations, and clues in the context of effectiveness. Moreover, special education teachers' view whose students participated to the study were explored. Even tough current study can provide results to explore the effectiveness of mobile writing application for supporting handwriting acquisition of students with dysgraphia, following suggestions would be needed for future research:

- In order to examine effectiveness longitudinal studies could be administered.
- It can also be applied to normally developing children in the first grade to larger groups. Comparative studies could be applied.
- It can also be applied to normally developing children in early childhood education in order to prepare for writing.
- Mobile writing application could be converted to mobile adaptive learning system.
- New features (audible version of letter, syllabi and words, changeable line space, reminder images of letters and words) can be added to mobile writing application for future studies.
- An application can be developed to allow the practitioners to add practices.
- It can also be used for teaching manuscript handwriting instead of cursive handwriting.
- Usability studies can be administered.
- The content of mobile writing application can be varied (correct pen grip, line activities, writing sentence, paragraph, adding spelling, and syntax rules).
- This study could be developed with the use of "gamification". Small games can also be integrated between the main parts. Studies could investigate the

impact of gamification in teaching writing for students with dysgraphia with the use of the mobile application.

- This study brought a perspective on the commonly challenged letters, syllables and words that are encountered in writing. These areas could be explored in further studies with alternative methods. This study could be developed through the use of action research in a way to help teachers to teach better and students learn better.
- A new version can be developed for left-handed students.
- Pen that is more realistic can be developed to use with mobile writing application.
- New technologies like haptic or robotic can be integrated in future research. Pen can give feedback about correct pen grip to students.
- It can be applied with more students or different types of disabilities. The application could further be analyzed based on the experiences of students with different types of disabilities.
- This study could be analyzed from the gendered perspective and further studies could analyze the impact of gender in teaching writing with the help of mobile application. Larger groups could be used to get general picture.
- The use of mobile writing application out-of-school and interaction with parents can be examined.
- It could be applied on socio-economically different groups of students with learning disabilities. Familial and demographic factors could be investigated to bring perspectives for the teachers and the parents. In line with the demographic and family factors, teacher training and family training seminars could be tailored to meet the needs of families and schools.

5.6 Limitations

The limitations of this study could be listed as below:

- The number of students participated in this study is limited to 11 in two special education and rehabilitation centers in Istanbul.

- The content of mobile application is limited to uppercase and lowercase letters, numbers, syllabi and words (454 items in total).
- The duration of the treatment is limited to students' own pace.
- Due to the nature of research method employed, purposeful sampling method was used and it is a limitation for generalization.

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APPENDIX A

MOBILE WRITING APPLICATION EVALUATION FORM (TURKISH)

ÖZEL EĞİTİM UZMANINA SORULAR:

Algılanan Kullanım Kolaylığı

Yazma uygulamasının kullanımını öğrenmek öğrenciler için kolay mıdır?

Yazma uygulamasını kullanmak öğrenciler için kolay mıdır?

Yazma uygulamasında deneme ekranı uygulamaya başlamak için yeterli desteği sağlamakta mıdır?

Yazma uygulamasında kullanılan sesli ve yazılı yönergeler disgrafi yaşayan öğrenciler için açık, anlaşılır ve yönlendirici midir?

Kalemin kullanımı kolay mıdır?

Algılanan Yarar

Yazma uygulaması öğrencilerin yazma becerisini kazanmasını kolaylaştırmakta mıdır?

Yazma uygulamasını kullanmaları öğrencilerin akademik performansını yükseltebilir mi?

Yazma uygulaması öğrencilerin kendi hızında ilerlemelerine yardımcı olmakta mıdır?

Yazma uygulaması yeterli miktarda alıştırma olanağı sağlamakta mıdır?

Yazma uygulaması yazma becerisini destekleme konusunda faydalı mıdır?

Genel olarak yazma uygulaması disgrafi yaşayan öğrencilerin gereksinimlerini karşılar nitelikte midir?

Algılanan Eğlence

Yazma uygulaması ile öğrenmek öğrenciler için eğlenceli midir?

Yazma uygulaması öğrencinin ilgisini çeker nitelikte midir?

Yazma uygulaması öğrenciyi motive edici nitelikte midir?

Yazma uygulamasını kullanırken öğrenci zevk alır mı?

Eğitsel İçerik

Yazma uygulaması içeriğinin;

Kapsamı

Uygulama miktarı

Sunulması disgrafi yaşayan öğrenciler için uygun mudur?

Yazma uygulamasında kullanılan

ipuçları,

dönütler,

pekiştireçler disgrafi yaşayan öğrenciler için uygun mudur?

Yazma uygulamasında sunulan ön test son test amaca uygun mudur?

Uygulama disgrafi yaşayan öğrenciler göz önüne alındığında yaş, sınıf, engel düzeyi açısından uygun mudur?

Arka planda tutulan öğrenciye ait veriler yeterli midir?

Görsel Tasarım

Yazma uygulamasının görsel tasarımı disgrafi yaşayan öğrenciler için uygun mudur?

Ekran Tasarımı

Ekran Yerleşimi

Kullanılan Renkler

Kullanılan Karakterler

Butonlar (düğmeler)

Metinler

Çoklu Ortam Özellikleri:

Yazma uygulamasındaki animasyonların kullanımı uygun mudur?

Yazma uygulamasındaki animasyonlardaki yeniden oynatma özelliği uygun mudur?

Yazma uygulamasında kullanılan sesler (yönergeler, arka plan müzikleri, dönütlerde ve pekiştireçlerde kullanılanlar) disgrafi yaşayan öğrenciler için uygun mudur?

Yazma uygulamasındaki müzikler için durdurma, ileri, geri, yeniden oynatma özellikleri uygun mudur?

Eklemek istedikleriniz:

Güçlü Yönler:

Zayıf Yönler:

Diğer:

SINIF EĞİTİMİ UZMANINA/SINIF ÖĞRETMENİNE SORULAR:

Algılanan Kullanım Kolaylığı

Yazma uygulamasında deneme ekranı uygulamaya başlamak için yeterli midir?

Sunulan sesli ve yazılı yönergeler yeterli midir?

Becerilerin kazanılması için uygulama ortamı ve kullanılan kalem uygun mudur?

Algılanan Yarar

Yazma uygulaması öğrencilerin yazma becerisini kazanmasını kolaylaştırmakta mıdır?

Yazma uygulamasını kullanmaları öğrencilerin akademik performansını yükseltebilir mi?

Yazma uygulaması öğrencilerin kendi hızında ilerlemelerine yardımcı olmakta mıdır?

Yazma uygulaması yeterli miktarda alıştırma olanağı sağlamakta mıdır?

Yazma uygulaması yazma becerisini destekleme konusunda faydalı mıdır?

Eğitsel İçerik

Uygulama içeriği öğrencilerin ilgili becerileri (kazanımları) elde etmesine yönelik midir?

Ön test-son test öğrencilerin yazma becerilerini ölçmek için yeterli midir?

Sunulan ipuçları yeterli (1. derece, 2. derece ve 3. derece) midir?

Sunulan dönütler yeterli midir?

Yazma uygulaması içeriğinin;

Kapsamı,

Uygulama miktarı,

Sunulması yeterli midir?

Ekrandaki yazı alanının ölçüsü beceri öğretimi için uygun mudur?

Uygulamada kullanılan sesler içerik açısından uygun mudur?

Eklemek istedikleriniz:

Güçlü Yönler:

Zayıf Yönler:

Diğer:

EĞİTİM TEKNOLOJİSİ UZMANLARINA SORULAR:

Algılanan Kullanım Kolaylığı

Yazma uygulamasının kullanımını öğrenmek öğrenciler için kolay mıdır?

Yazma uygulamasını kullanmak öğrenciler için kolay mıdır?

Yazma uygulamasında deneme ekranı uygulamaya başlamak için yeterli desteği sağlamakta mıdır?

Yazma uygulamasında kullanılan sesli ve yazılı yönergeler disgrafi yaşayan öğrenciler için açık, anlaşılır ve yönlendirici midir?

Kalemin kullanımı kolay mıdır?

Algılanan Yarar

Yazma uygulaması öğrencilerin yazma becerisini kazanmasını kolaylaştırmakta mıdır?

Yazma uygulamasını kullanmaları öğrencilerin akademik performansını yükseltebilir mi?

Yazma uygulaması öğrencilerin kendi hızında ilerlemelerine yardımcı olmakta mıdır?

Yazma uygulaması yeterli miktarda alıştırma olanağı sağlamakta mıdır?

Yazma uygulaması yazma becerisini destekleme konusunda faydalı mıdır?

Algılanan Eğlence

Yazma uygulaması ile öğrenmek öğrenciler için eğlenceli midir?

Yazma uygulaması öğrencinin ilgisini çeker nitelikte midir?

Yazma uygulaması öğrenciyi motive edici nitelikte midir?

Yazma uygulamasını kullanırken öğrenci zevk alır mı?

Eğitsel İçerik

Yazma uygulamasında kullanılan

ipuçları,

dönütler,

Pekiştireçlerin sunum şekli uygun mudur?

Görsel Tasarım

Yazma uygulamasının görsel tasarımı eğitsel açıdan uygun mudur?

Ekran Tasarımı

Ekran Yerleşimi

Kullanılan Renkler

Kullanılan Karakterler

Butonlar (düğmeler)

Metinler

Çoklu Ortam Özellikleri

Yazma uygulamasındaki animasyonların kullanımı uygun mudur?

Yazma uygulamasındaki animasyonlardaki yeniden oynatma özelliği uygun mudur?

Yazma uygulamasında kullanılan sesler (yönergeler, arka plan müzikleri, dönütlerde ve pekiştireçlerde kullanılanlar) eğitsel açıdan uygun mudur?

Yazma uygulamasındaki müzikler için durdurma, ileri, geri, yeniden oynatma özellikleri uygun mudur?

Teknik Özellikler

Uygulamanın kolayca yüklenebilmesi söz konusu mudur?

Uygulama hatasız çalışmakta mıdır?

Eklemek istedikleriniz:

Güçlü Yönler:

Zayıf Yönler:

Diğer:

APPENDIX B

INTERVIEW QUESTIONS FOR AFTER THE EXPERIMENT (PSYCHOLOGIST, PSYCHOLOGICAL COUNSELOR, SPECIAL EDUCATION SPECIALIST) (TURKISH)

1. Öğrenciler için uygulamanın kullanımını nasıl bulduğunuzu tanımlar mısınız? (Algılanan Kullanım Kolaylığı)
2. Öğrenciler için uygulamanın ve kalemin kullanımını nasıl buldunuz? (Algılanan Kullanım Kolaylığı) (Algılanan Yarar)
3. Mobil uygulamayı başka bilgi ve becerilerin öğretiminde kullanmayı düşünürseniz, bunlar neler olabilir? (Algılanan Yarar)
4. Öğrencinizin bu uygulamayı kullanma sürecinde;
5. Yazma becerisini geliştirdiğini (Algılanan Yarar)
6. Yazmaya karşı daha olumlu tutum geliştirdiğini (Eğlence)
7. Uygulamayı kullanırken eğlendiğini düşünüyor musunuz? (Eğlence)
8. Uygulamanın öğrencileri motive ettiğini (Eğlence)
9. Uygulamayı kullanırken memnun kaldığını düşünüyor musunuz? (Memnuniyet)
10. Uygulama hakkındaki görüşleriniz nelerdir?
11. Mobil yazma uygulamasının Olumlu Özellikleri (İyi yönleri):
12. Mobil yazma uygulamasının Geliştirilmesi Gereken Özellikleri:

APPENDIX C

OBSERVATION FORM (TURKISH)

Adı Soyadı:

Uygulama Tarihi:

Eylemler
Konuşma
Ayağa kalkma
Başka bir yere bakma
Boş durma (Ara verme)
Başka bir şeyle ilgilenme
Bir şeyle oynama
Kıpırdanma
Yönergeleri İzlememe

APPENDIX D

PRETREATMENT QUESTIONNAIRE (TURKISH)

1. Öğrenci Kodu:
2. Öğretmen/Psikolog/Psikolojik Danışman Adı Soyadı:
3. Veli Kodu:
4. Cinsiyet:
5. Doğum Tarihi:
6. Sınıf:
7. Okul: □ Özel □ Devlet
8. Öğrencinin özel öğrenme güçlüğü tanısı kim tarafından ve ne zaman konuldu?
9. Devam ettiği özel eğitim merkezi veya danışmanlık merkezi:
10. Ne zamandır destek almaya devam ediyor?
11. Öğrencinin özel öğrenme güçlüğü tanısı kim tarafından ve ne zaman konuldu?
12. Öğrencinin okul dışındaki eğitimi ile kim(ler) ilgileniyor?

□ Anne □ Baba □ Abi/Abla □ Özel Öğretmen □ Özel Eğitim/Danışmanlık Merkezi □ Diğer

13. Tableti var mı?/Daha önce tablet kullandı mı?
    a. Tableti hangi amaçla kullandı?
    b. Tablet kalemi kullandı mı?
14. Ders/seanslarda dikkatini sürdürme becerisi nasıldır? Kaç dakikadır?
15. Akademik başarısı nasıldır? (Not ortalaması vb…)
16. Özel ihtiyaçları nelerdir?
17. Öğrencinin tercih ettiği/sevdiği etkinlik/yiyecek?
18. Üstün/güçlü yönleri nelerdir?
19. Geliştirilmesi gereken yönleri nelerdir?
20. Görüşler:

APPENDIX E

PRETEST-POSTTEST FORM (TURKISH)

	Tamamen Yeterli (3)	**Orta Düzeyde Yeterli (2)**	**Hiç Yeterli Değil (1)**
Eğim	Harfler yaklaşık 60-70 derecelik bir eğimle metin boyunca düzgün ve sağa yatık olarak yazılmıştır. ( )	Harfler ölçülere uygun olmasa da sağa yatık olarak yazılmış ve bu yatıklık metin boyunca kısmen devam etmektedir. ( )	Harflerin eğimi oldukça düzensiz, eğimin yönü tutarsızlık göstermektedir. Dik, sola ve /veya sağa yatık harfler bir arada görülmektedir. ( )
Boşluk	Harfler, kelimeler ve cümleler arasındaki boşluk uygun ve metin boyunca tutarlı bir şekilde devam etmektedir. ( )	Harfler, kelimeler ve cümleler arasındaki boşluklarda bazı tutarsızlıklar vardır. Boşluklar metnin tamamında tutarlı değildir. ( )	Harfler, kelimeler ve cümleler arasındaki boşluklar uygun olmayıp, metnin tamamında tutarsızlık görülmektedir. ( )
Ebat	Harfler rahatça okunacak büyüklükte ve bu büyüklük metnin tamamında tutarlıdır. Büyük küçük harf oranı tamamen uygundur. ( )	Harflerinin ebatları normalden büyük ya da küçük olmasına rağmen tutarlıdır. Büyük küçük harf oranlarında da bazı tutarsızlıklar vardır. ( )	Harflerin ebatları düzensizdir. Metnin genelinde büyük küçük harf oranlarında tutarsızlık görülmektedir. ( )
Biçim	Harfler kurallarına uygun olarak yazılmıştır. Başlama ve bitiş yerleri uygun ve doğru şekilde yapılmıştır. Alt ve üst uzantılar ile gövde kısımları orantılıdır. Harf birleştirmeleri oldukça düzgündür. ( )	Harflerin başlama ve bitiş yerlerinde, alt ve üst uzantıları ile gövde kısımlarında bazı yanlışlıklar yapılmıştır. Harf birleştirmeleri kısmen düzgündür. ( )	Harflerin yazılışları, alt ve üst uzantıları ile gövde kısımlarının, başlama ve bitiş yerleri hatalıdır. Harf birleştirmeleri de nerdeyse hiç düzgün değildir. ( )
Çizgi Takibi	Satır çizgisi oldukça düzgün takip edilmiş, satır çizgisinden sapma, üste veya alta çıkma ve satır sonunda çizgiden taşma yapılmamıştır. ( )	Satır çizgisinin takibinde bazen sıkıntılar görülmektedir. Kısmen alta veya üste sapmalarla birlikte satır sonu taşmaları da görülebilmektedir. ( )	Satır çizgisi takibi oldukça yetersizdir. Alta veya üste sapmalar sürekli görülmekte, satır sonu taşmaları da oldukça fazla yapılmaktadır. ( )
Toplam Okunaklılık Puanı:			
( ) Okunaklı(11.8-15) ( )Orta Düzeyde Okunaklı (8.4-11.7) ( )Okunaklı Değil (5 – 8.3)			

APPENDIX F

ETHICS COMMITTEE OF MIDDLE EAST TECHNICAL UNIVERSITY RESEARCH CENTER FOR APPLIED ETHICS APPROVAL FORM (TURKISH)

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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Sayı: 28620816 / 127

22 MART 2016

Gönderilen: Doç.Dr. S.Tuğba TOKEL
Bilgisayar ve Öğretim Teknolojileri Eğitimi

Gönderen: Prof. Dr. Canan SÜMER
İnsan Araştırmaları Komisyonu Başkanı

İlgi: Etik Onayı

Sayın Doç.Dr. S.Tuğba TOKEL danışmanlığını yaptığı Sinan HOPCAN, Elif Polat HOPCAN, Kürşat ÇAĞILTAY, Necdet KARASU, Çığıl AYKUT, Gülşah Batdal KARADUMAN'ın "Disgrafi Yaşayan Öğrencilerin Yazma Becerisini Desteklemek İçin Geliştirilen Mobil Bir Yazma Uygulamasının Etkililiğinin Değerlendirilmesi" başlıklı araştırması İnsan Araştırmaları Komisyonu tarafından uygun görülerek gerekli onay **2016-EGT-036** protokol numarası ile **28.03.2016-01.01.2017** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Canan SÜMER
Uygulamalı Etik Araştırma Merkezi
İnsan Araştırmaları Komisyonu Başkanı

Prof. Dr. Meliha ALTUNIŞIK
İnsan Araştırmaları Komisyonu
Üyesi

Prof. Dr. Ayhan SOL
İnsan Araştırmaları Komisyonu
Üyesi

Prof. Dr. Mehmet UTKU
İnsan Araştırmaları Komisyonu
Üyesi

Yrd.Doç.Dr. Pınar KAYGAN
İnsan Araştırmaları Komisyonu
Üyesi

APPENDIX G

PARENTAL CONSENT FORM (TURKISH)

Sayın Veli,

Çalışmayı yürüten Sinan Hopcan, Orta Doğu Teknik Üniversitesi, Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümünde doktora öğrencisi olarak çalışmaktadır. Bu doktora tez çalışması Orta Doğu Teknik Üniversitesi öğretim üyesi Yrd. Doç. Dr. S. Tuğba Tokel danışmanlığında yürütülmektedir. Çalışmanın amacı yazma güçlüğü yaşayan bireylere yazma becerileri öğretiminde eğitsel tablet bilgisayar uygulamasının etkisini araştırmaktır.

Çocuğunuz ile yazma uygulamasına ilişkin çalışmalar yürütülecektir. Çalışma çocuğunuz için psikolojik veya fiziksel bir risk taşımamaktadır. Çalışmaya katılım tamamen gönüllüdür, çalışma sürecinde istediğiniz zaman çocuğunuzun katılımını engelleyebilir ve çalışmayı bırakabilirsiniz. Çalışma sırasında bilimsel değerlendirme amaçlı görüntü kaydı alınacaktır. Çalışmada gizlilik esas olacak, çocuğunuzun ismi hiçbir yerde rapor edilmeyecektir. Sinan Hopcan çalışma süresince kendisine soracağınız tüm sorulara cevap verecektir.

Çalışmaya ya da çocuğunuzun katılımına yönelik daha fazla bilgi için başvurulacak kişi Sinan Hopcan'dır. Telefon: …… E-posta Adresi: sinan.hopcan@gmail.com

İlginiz için teşekkürler,

Sinan Hopcan

Yukarıda açıklamasını okuduğum çalışmaya, oğlumun / kızımın katılımına izin veriyorum.

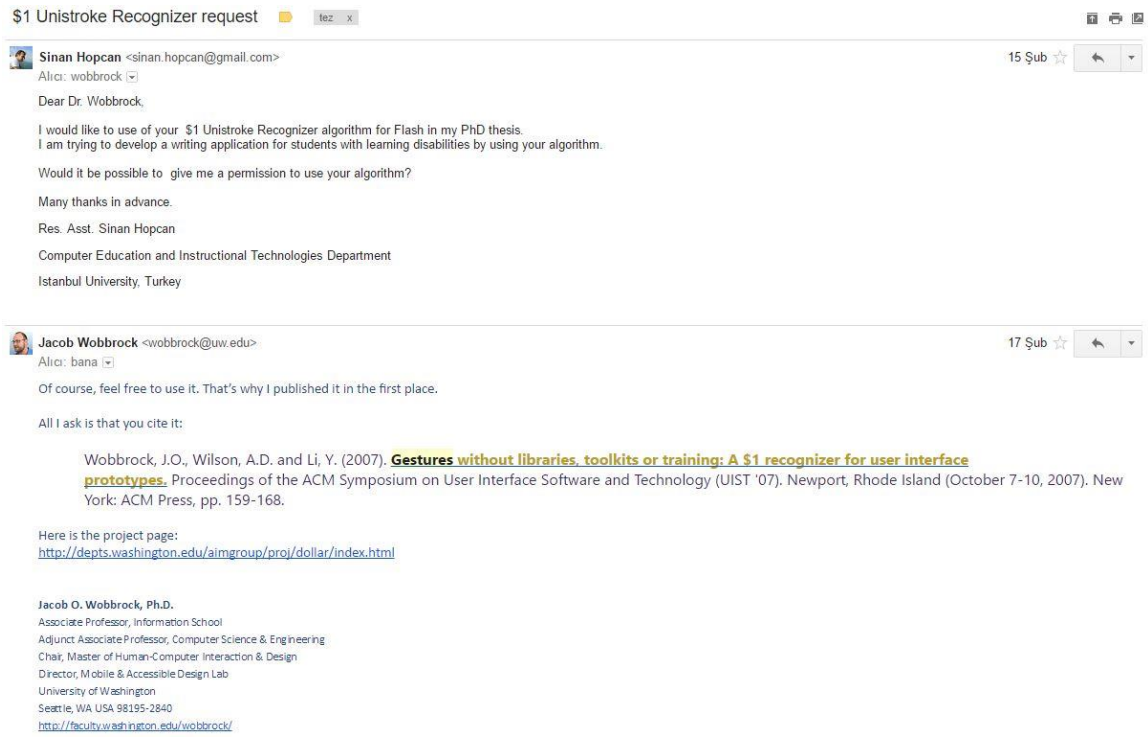
Velinin:

Adı Soyadı: _____ İmzası: _____

Tarih:_____

APPENDIX H

PERMISSION FROM THE GESTURE RECOGNITION ALGORITM DEVELOPER



$1 Unistroke Recognizer request tez x

Sinan Hopcan <sinan.hopcan@gmail.com> 15 Şub

Alıcı: wobbrock

Dear Dr. Wobbrock,

I would like to use of your $1 Unistroke Recognizer algorithm for Flash in my PhD thesis.
I am trying to develop a writing application for students with learning disabilities by using your algorithm.

Would it be possible to give me a permission to use your algorithm?

Many thanks in advance.

Res. Asst. Sinan Hopcan

Computer Education and Instructional Technologies Department

Istanbul University, Turkey

Jacob Wobbrock <wobbrock@uw.edu> 17 Şub

Alıcı: bana

Of course, feel free to use it. That's why I published it in the first place.

All I ask is that you cite it:

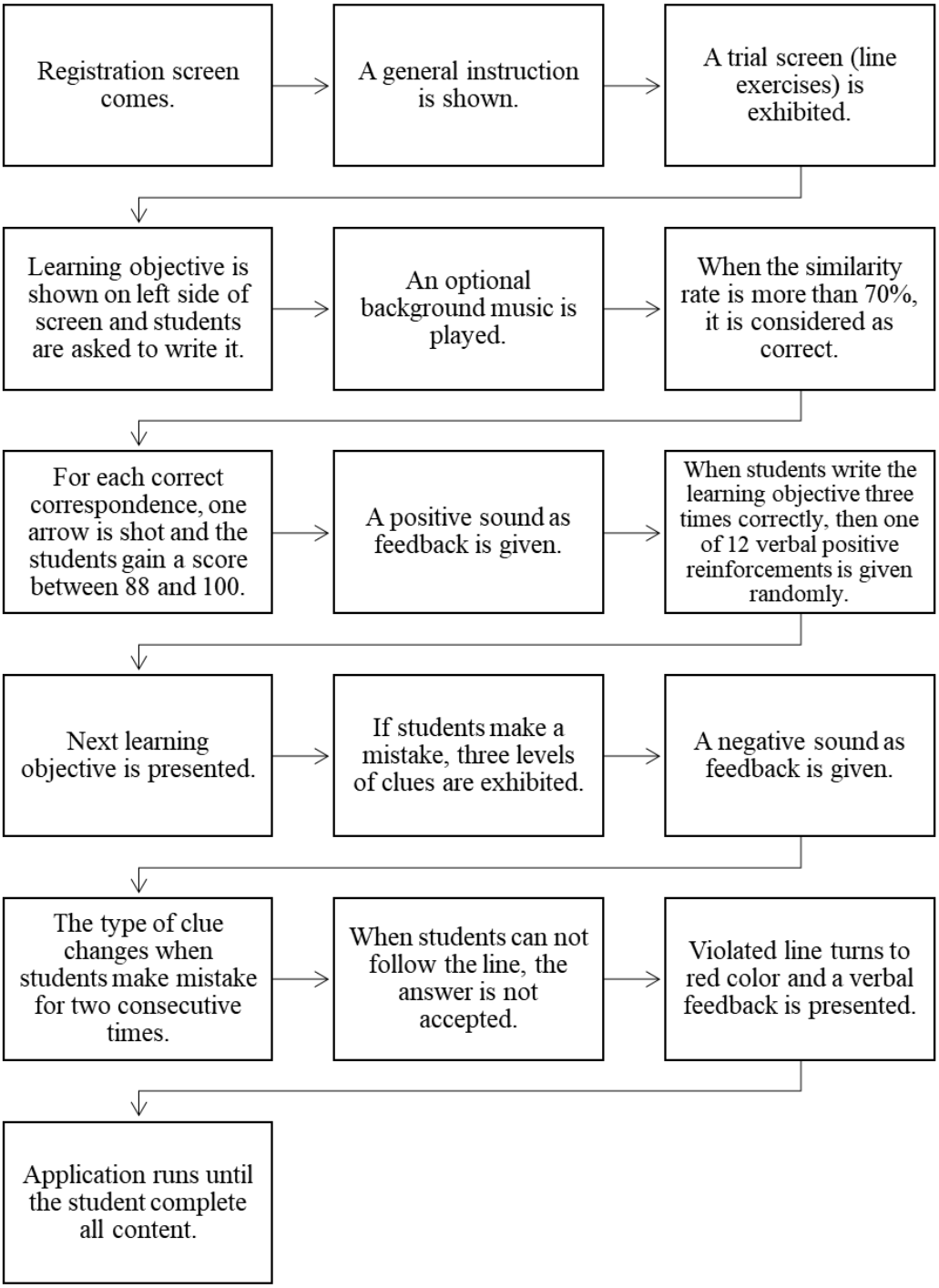
> Wobbrock, J.O., Wilson, A.D. and Li, Y. (2007). **Gestures without libraries, toolkits or training: A $1 recognizer for user interface prototypes.** Proceedings of the ACM Symposium on User Interface Software and Technology (UIST '07). Newport, Rhode Island (October 7-10, 2007). New York: ACM Press, pp. 159-168.

Here is the project page:
http://depts.washington.edu/aimgroup/proj/dollar/index.html

Jacob O. Wobbrock, Ph.D.
Associate Professor, Information School
Adjunct Associate Professor, Computer Science & Engineering
Chair, Master of Human-Computer Interaction & Design
Director, Mobile & Accessible Design Lab
University of Washington
Seattle, WA USA 98195-2840
http://faculty.washington.edu/wobbrock/

APPENDIX I

FLOW CHART OF MOBILE WRITING APPLICATION



CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Hopcan, Sinan

Nationality: Turkish (T.C.)

Marital Status: Married

e-mail: sinan.hopcan@istanbul.edu.tr

EDUCATION

2013 - 2017 Middle East Technical University, Institute of Science, Computer Education and Instructional Technology, Ph.D.

2010 - 2013 Sakarya University, Institute of Educational Science, Computer Education and Instructional Technology, M.S.

2006 - 2010 Yıldız Technical University, Faculty of Education, Department Of Computer Education and Instructional Technology

2000 - 2004 AKSA Anatolian Vocational High School, Yalova, Department of Computer/Software

WORK EXPERIENCE

Year	Place	Enrollment
2012 November-present	Istanbul University Faculty of Education	Research Assistantship (RA)
2015 July-2015 September	New York University-CREATE LAB	Visiting Scholar
2010 November-2012 November	Bahçeşehir University	Research Assistantship (RA)
2010 October-2010 November	İstanbul University	Software Devoloper

FOREIGN LANGUAGES

Advanced English

PROJECTS

April 2013 –April 2015	TUBITAK 1010 EVRENA Project. "The Role of Migration in School Engagement: The Effect of Social Capital, Psychological and Cultural Processes on High School Success**"** Position: Scholarship Student
June 2012 – June 2013	Sakarya University. BAP. "Reduction of Specific Learning Difficulties Through the Web-Based Adaptive System" Position: Researcher
May 2011- June 2012	TUBITAK 4004 Project "Changing Lives Through Technology" Position: Researcher/Specialist

PUBLICATIONS

Peer Reviewed Publications

Bayraktar, D. M., Hopcan, E. P., & Hopcan, S. (2013). Adoption of Social Networks and Loneliness Situations of Candidate Teachers. *Hasan Ali Yücel Eğitim Fakültesi Dergisi, 10*(2), 35-45.

Hopcan, S., & Yılmaz, M. B. (2013). Ilköğretim Öğrencilerinin Internet Kafe Kullanimlarinin Farkli Değişkenlere Göre Incelenmesi. *Hasan Ali Yücel Eğitim Fakültesi Dergisi*, *10*(2), 23-34.

Hopcan, S., Polat, E., & Adiguzel, T. (2014). Çift anadal programında okuyan öğrencilerin görüşleri: Bir değerlendirme çalışması. *Hasan Ali Yücel Egitim Fakültesi Dergisi, 11*(22), 287-299.

CONFERENCE PRESENTATIONS & PROCEEDINGS

Hopcan, S., Tokel, T., & Karasu, N. (2016). Disgrafi Yaşayan Öğrencilerin Yazma Becerisini Desteklemek İçin Geliştirilen Mobil Bir Yazma Uygulamasının Etkililiğinin Değerlendirilmesi. Eğitimde FATİH Projesi Eğitim Teknolojileri Zirvesi, Ankara.

Hopcan, S., Tokel, T. Karasu, N., & Aykut, Ç. (2016). Disgrafi Yaşayan Öğrencilerin Yazma Becerisini Desteklemek İçin Mobil Bir Yazma Uygulamasının Geliştirilmesi. 26.Ulusal Özel Eğitim Kongresi, Eskişehir.

Hopcan, S., Polat, E., İlhan, F. & Tokel, T. (2016). A 3D Learning Environment for Students with Specific Learning Disabilities in 1st - 3rd Grades: A Design and Development Study. In Proceeding ICITS 2016, Rize.

Kefeli, P., Polat, E. & Hopcan, S. (2016). The Perception of High School Students, Their Parents and Teachers About Essay Tests, ICITS 2016, Rize.

Hopcan, S., & Polat,E. (2013). Fatih Projesi E-içerik: 9.-12. Sınıf Kazanım Bazlı Coğrafya Videolarına İlişkin Öğretmen Görüşleri. 1st International Instructional Technologies & Teacher Education Symposium, Trabzon.

Ağır, A., Polat,E., & Hopcan, S. (2012). 9.-12.Sınıf Kazanım Bazlı Coğrafya Videolarına İlişkin Öğrenci Görüşleri. ICITS 2013, Erzurum.

Hacıfazlıoğlu, Ö., Karadeniz, Ş., Polat, E., & Hopcan, S. (2012). "Uzaktan Eğitim Yönetiminde İleri Teknoloji Uygulamaları". III. İleri Teknolojiler Çalıştayı, İstanbul, 2-6 Ekim.

Hopcan, S., & Yılmaz, M. B. (2012). İlköğretim Öğrencilerinin İnternet Kafe Kullanımlarının Farklı Değişkenlere Göre İncelenmesi. International Computer & Instructional Technologies Symposium, Gaziantep, Turkey.

Polat, E., Hopcan, S., & Adiguzel, T. (2011). Yükseköğretimde Çift Anadal Programlarının Bütüncül Değerlendirilmesi: Örnek Bir Çalışma. Paper presented at the annual meeting of the International Higher Education Congress: New Trends and Issues (UYK-2011), Istanbul.

Hopcan, S., Polat, E., Irak, M., & Adiguzel, T. (2011). Computerizing The Cancellation Test: Design, Development And Validation Study. Paper presented at the annual meeting of the International Educational Technology Conference, Istanbul.

Polat, E., Hopcan, S., Albayrak, E., & Akgün, Ö. E. (2011). Böte Mezun Adaylarının Yapmak İstedikleri Mesleğe Yönelik Görüşleri. International Educational Technology Conference, Istanbul.