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TEACHING CONCEPTS TO STUDENTS WITH VISUAL IMPAIRMENTS: TOUCH-LISTEN-LEARN MODEL[1]

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ABSTRACT

Visual representations, such as graphics and shapes, are modes of presenting information that can pose a challenge for individuals with visual impairments. To address this issue, mobile technologies that provide tactile and auditory stimuli have been developed to ensure equal learning opportunities for individuals with visual impairments. The study investigates the extent to which Touch-Listen-Learn model, implemented through Tactile Images Reader mobile application, contributes to the concept teaching of students with visual impairments. This study used the Touch-Listen-Learn model to teach concepts to three secondary school students with visual impairments. Each student used, only tactile material, tactile material with audio description, and the Touch-Listen-Learn model. Students with visual impairments were able to actively participate in the concept teaching through the Touch-Listen-Learn Model. The results suggest that the use of the Touch-Listen-Learn model could support independent and self-paced visual information learning among students with visual impairment.
Keywords: visual impairments, touch-listen-learn model, tactile material, assistive technology.

GÖRME YETERSİZLİĞİ OLAN ÖĞRENCİLERİN DOKUN-DUY-ÖĞREN MODELİ İLE KAVRAM ÖĞRENİMİ DENEYİMİ

ÖZ

Bilginin sunum şekillerinden olan grafik, şekil gibi görsel temsiller görme yetersizliği olan bireyler için bir sınırlılıkken, dokunsal ve işitsel uyaranlara hitap edecek şekilde geliştirilmiş mobil teknolojiler görme yetersizliği olan bireyler için eğitimde bağımsız öğrenme ve fırsat eşitliği sağlamada son derece önemlidir. Bu bağlamda, çalışmada birden fazla duyu organına hitap eden Tactile Images Reader mobil uygulaması (TIR) kullanılarak Dokun-Duy-Öğren modelinin görme yetersizliği olan öğrencilerin bireysel ve bağımsız bir şekilde kavram öğrenimine nasıl katkı sağladığının belirlenmesi amaçlanmıştır. Çalışma kapsamında Dokun-Duy-Öğren modeli ile kavram öğrenimi görme yetersizliğinden etkilenmiş üç öğrencinin deneyimi ile gerçekleştirilmiştir. Öğrenciler sırasıyla kabartma/dokunsal materyali sadece dokunsal; sesli betimleme eşliğinde dokunsal; son olarak TIR destekli Dokun-Duy-Öğren modeli ile kavram öğrenimi sürecine etkin katılım sağlamıştır. Bu araştırmanın sonucuna göre çalışmaya katılan öğrencilerin, TIR kullanarak Dokun-Duy-Öğren modelinin eğitimde kullanılmasının, bağımsız ve kendi hızında görsel bilgileri öğrenmelerini destekleyeceği yönünde görüşleri olduğu tespit edilmiştir.
Anahtar kelimeler: görme yetersizliği, dokun-duy-öğren modeli, kabartma/dokunsal materyal, yardımcı teknoloji.

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INTRODUCTION

While sighted students acquire information through the sense of sight and visual clues (Ataman, 2003; Özkan, 2013), students with visual impairments acquire information through sense organs other than vision (Sleezer et al., 2014; Zorluoğlu, 2020). Students with visual impairments lack the ability to have visual experiences during learning, leading to challenges in learning situations compared to their sighted peers (Zebehazy et al., 2012).

Students with visual impairments require instructions that consider the barriers to effective learning in order to mitigate their educational deficiencies and enhance the effectiveness of their learning experiences (Çalışkan & Çangal, 2013). Due to the fact that many concepts encountered in daily life are acquired through the visual sensory channel, it is believed that students with visual impairments may have difficulty learning these concepts effectively because many of the concepts acquired through sight are too large, too dangerous, or too abstract to be touched. Consequently, individuals with visual impairments experience difficulties in both the perception and understanding of these concepts (Gupta et al., 2017; Wild & Koehler, 2017).

Students with visual impairments, who face challenges in perception and understanding subjects and concepts, are generally taught using braille, tactile materials, or documents with large print (Martiniello et al., 2022). These materials support a sensory organ other than vision; however, they prove insufficient in catering to the needs of multiple sensory organs simultaneously (Gomes et al., 2020; Wild & Koehler, 2017). In order to effectively learn from these materials, learners frequently require additional support, often finding themselves in a position where they are forced to either seek support or memorize, leading to ineffective learning. Alternative learning materials are required for students with visual impairments to be able to learn effectively (Kapucu & Kızılaslan, 2022). Because activating the sensory organs actively used by students with visual impairments in the learning of concepts enhances the effectiveness of learning (Hatlen, 2010).

Throughout their daily experiences, students with visual impairments are acquiring knowledge in areas such as education, economics, and social skills, but they constantly need others for assistance; tactile and auditory materials; or materials combining tactile and auditory interaction and support independent and active learning, require support throughout the day (Beck-Winchatz & Riccobono, 2008; Gürsel, 2012; Maćkowski et al., 2022; Yazıcı, 2017). In order to facilitate learning or teaching a concept, students must be provided with environments that provide them with opportunities to experience and be supported in a variety of ways (braille, audio description, etc.) rather than teaching only through presentation, which is one of the direct expression methods. (Lin, 2004; Miles & McLetchie, 2008; Rosenblum et al., 2019). Nonetheless, Braille outputs have the potential to loss of time, and audio descriptions can cultivate a dependency on external assistance. Mobile applications developed recently to support individual learning and facilitate daily life (Bandyopadhyay & Rathod, 2017; Nikolopoulou & Kousloglou, 2019; Qutieshat et al., 2019) have started to be used in various aspects of life, including education and daily routines. Indeed, the Tactile Images Reader (TIR), supported by a mobile application, designed to activate both tactile and auditory stimuli, has been noted to enhance the effectiveness of visuals that aid students with visual impairments in acquiring information and support individual learning and facilitate the learning of concepts at their own pace in daily life (Patrascoiu et al., 2022).

An exploration of the academic literature reveals studies conducted on concept teaching that incorporate tactile materials (Park & Hong, 2022), mobile applications (Beal & Rosenblum, 2015; Buzzi et al., 2015; Ranjan et al., 2019), and auditory materials (Milne et al., 2015; Lahav et al., 2018) developed specifically for students with visual impairments. Within this research, it is acknowledged that students with visual impairments learn the relevant concepts, and it is emphasized that individual learning should be supported by including different sensory organs for independent learning of the concepts. Furthermore, in light of the substantial costs associated with assistive technology devices tailored for individuals with visual impairments, it is known that these

mobile applications also provide access to information that can appeal to multiple sensory organs simply through smartphones. Hence, the objective of this research is to determine supporting individual learning (Drigas & Papoutsi, 2021), and addressing multiple sensory organs (Patrascoiu et al., 2022) how contribute to the conceptual learning of students with visual impairments. In pursuit of this objective, within the scope of the study, students with visual impairments were facilitated to independently learn the concept of a bus from public transportation vehicles through the TIR application employing the Touch-Listen-Learn model. It is important to note that the results obtained in this study are likely to form the basis for future studies in which variables such as motivation, attitude, and achievement can be examined in concept learning using the Touch-Listen-Learning model.

ACTIVITY IMPLEMENTATION

Participants

In this study, three male middle school students with visual impairments participated voluntarily. The participants were reached via the Kapsayıcı ve Erişilebilir Yaşam Association, situated in the Ankara province. Each of these students had no other needs that could entirely hinder their learning, and they are deemed suitable to receive educational support from the Guidance and Research Center. Having basic-level skills in smartphone usage was considered a sufficient qualification for participation in this research.

Participant S1 was 12 years old and attended the sixth grade at a state school for the blind, which is affiliated with the Ministry of National Education (MEB). He has a visual impairment classified as "Leber's Congenital Amarousis" with a disability status defined at 95% and above. Braille (embossed) writing was his primary source of learning.

S2, was 11 years old and attended the fifth grade at a state school for the visually impaired, which is affiliated with MEB. He had a visual impairment classified as " Nistagmus" with a disability status defined at 90% and above. Braille (embossed) writing was his primary source of learning.

S3 was 14 years old and attended the eighth grade in an inclusion program at a public school affiliated with MEB. He had a visual impairment classified as "Congenital cataract and glaucoma" with a disability status defined at 85% and above. Braille (embossed) writing and large print visual materials were his primary source of learning at the same time.

Learning with the Touch-Listen-Learn Model

The TIR application is required to implement learning with the Touch-Listen-Learn model. The TIR application is an interactive learning process that audibly describes embossed/tactile images. In other words, it involves presenting information simultaneously through tactile, auditory, and written channels to students with visual impairments during concept learning. In the Touch-Listen-Learn model, it is necessary to design embossed/tactile images for the related topics and concepts to activate the TIR application. The individual sections of the crafted embossed/tactile images are described separately in the drawing tool, and saved. The area touched by the student is verbally described through the TIR application. Thus, students with visual impairments can access the images independently. Detailed and effective learning is provided through the auditory description of the areas they touch. Additionally, instead of a tactile print of the designed image, the TIR application can work with a digital print on A4 paper, and the image can be made usable by embossing with handmade materials such as silicone on the visual. In learning with the Touch-Listen-Learn model, a student with visual impairments needs to open the TIR application and hold the phone/tablet's camera over the embossed/tactile image. This can be done by placing the phone on a phone holder with the camera facing downwards or by holding the phone steady in hand (See Appendix 1). Subsequently, maintaining a stationary position of the index finger steady on the QR code for 3 seconds enables the interaction between the TIR application and the tactile/embossed image.

Students with visual impairments can independently listen to the auditory descriptions of specific areas they touch by keeping their index finger steady on the area they want to examine, thus supporting their individual learning.

Pilot Study

The pilot study was conducted with two middle school students with visual impairments. During this pilot study, these participants were initially introduced to the tactile representation of a bus on the embossed concept paper. Subsequently, an integrated learning experience was facilitated by jointly presenting the TIR application and the tactile representation of the bus. As a result of the pilot study, shortcomings related to the embossed/tactile concept paper and the TIR application have been identified. For instance, appropriate lighting was used to ensure that the embossed images on the pages did not shine, allowing the mobile application to detect the touched area. Furthermore, modifications were instituted within the interview questions. Explanatory questions were added in cases where the original questions were not understood.

Implementation of the Application

After obtaining the necessary permissions (ethical committee approval from Süleyman Demirel University and voluntary participation forms from the families), the application was carried out. Within the conceptual learning framework of the Touch-Listen-Learn model, a three-stage method was followed to reveal students' independent and individual learning capacities and to emphasize the effectiveness of the Touch-Listen-Learn model. In the first session, a tactile concept paper related to the bus image (see Table 1) was presented (with Braille title and QR code labeled). In the second session, both the tactile concept paper related to the bus image and the written description paper (Table 2) were provided simultaneously. In the third session, the TIR application, which is the foundation of the Touch-Listen-Learn model, and the tactile image were presented together. Face-to-face engagement was established with a single student during each respective session, and three sessions were conducted with each student. Subsequent to each session, the students were interviewed with semi-structured questions about their learning experiences.

1. Learning the Concept of a Bus with Tactile/Embossed Image

The students were verbally instructed as follows: "Now, I want to do an activity with you that will take about 10 minutes. Are you ready? First, I will give you a tactile/embossed concept paper about the concept you are going to learn today. After you examine this tactile/embossed concept paper (Table 2), I will ask you questions, and I will wait for your answers. Now, I want you to touch the material I've placed in front of you until you understand it." (While the student was examining the embossed image of the bus, verbal instructions were given if necessary, and then physical assistance was provided. These hints were given to help the student examine the entire embossed image. The assistance was not related to what is in the image provided.) "When you say 'I understand,' I will start asking questions. Are you ready? I anticipate genuine responses to my questions sincerely and please think out loud." Subsequently, the interview questions were then proceeded.

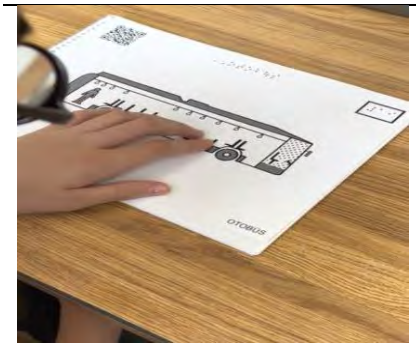
2. Learning the Concept of Bus with Tactile/Embossed Image and Written Description

At the end of the first session, after the interview questions, second session started. During the second session, concurrent with the tactile conceptual document, a descriptive text of the bus visual was furnished in braille and enlarged font, and right after, it was requested that this description be vocalized. “I will give you the written description along with the embossed/tactile concept paper that I gave you before. Now, I want you to first read the description out loud, and then examine the embossed/tactile concept paper again. When you say, 'Okay, I understand,' I will start asking questions. Are you ready? I expect you to give sincere answers to the questions I ask and to think out loud.”. The student was merely observed while reading the description of the bus visual and examining its embossing. Afterwards, interview questions were asked, and the student's responses were awaited (see Table 2).

3. Learning the Concept of Bus with the Touch-Listen-Learn Model

After the interview questions at the end of the second session, the third session started. In the third session, which taught the bus concept with the Touch-Listen-Learn model, the student was provided a phone with the TIR application and a tactile image of the bus. The student was introduced what the TIR application and how to use it. They were given the opportunity to use the application themselves to satisfy their curiosity and to adapt to it. Then the process progressed as follows: The process then proceeded as follows: "You will perform a technology-supported learning that enables you to examine the embossed/tactile concept image I gave you before independently and at your own pace with the Touch-Listen-Learn model. Utilizing the Touch-Listen-Learn model, you will be able to learn yourself by touching and listening to the application.

Table 1. Learning the Concept of Bus with Tactile/Embossed Visual

Pictures of During Learning	Description of the Learning Process
	**Researcher:** *Now I want you to touch the material I put in front of you until you understand it.* *S3, with one hand, moved his fingertips (except the thumb) horizontally from the wheel level to the right to move the bus visual to the top. There, he touched horizontally to the left, and with a quick scan (13 seconds) touching the person, the seats, and finally the handles inside, he returned to where he started.* **Researcher:** *What do you think could be the thing you touched on this paper? Why did you think like that?* **S3:** *It is a bus what I touched. Because it is long and has seats like a bus. There is a man inside the bus. I used both my touch and my sight here.* **Researcher:** *Do these types of tactile materials support your learning?* **S3:** *Even though I can use my vision, I can understand better in class if I have tactile [material] under my hand like this..*
	**Researcher:** *Now I want you to touch the material I put in front of you until you understand it.* *S2, quickly touched the image from top to bottom with both hands. He then completed a tour around the outline of the bus using his left index finger. During this process, he brought his eyes closer to the image.* **Researcher:** *What do you think could be the thing you touched on this paper? Why did you think like that?* **S2: :** *It is a bus what I touched. There is a door here. These types of materials support my learning, at least I know the shapes.* **Researcher:** *Were there any difficult points while experiencing this material?* **S2:** *The lines could have been a little more distinct. Braille text is not felt properly. The font size could have been bold and a little larger, and the visual could have been better if it had been white on a black background.*
	**Researcher:** *Now I want you to touch the material I put in front of you until you understand it.* *He quickly touched the outline of the bus on the visual with both hands and moved to the QR code in the upper right corner. (9 seconds) (I examined it, but it is easier with my eyes, it is a little harder with my hand, these are a little blurry [cannot be understood by touch]). He also used his vision, getting a little closer to the visual.* **Researcher:** *What do you think could be the thing you touched on this paper? Why did you think like that?* **S1:** *This is a bus. There are seats in, it is long, and there are wheels. There are handles here where I touched. I had taken the bus before.* **Researcher:** *Were there any difficult points while experiencing this material?* **S1:** *If the description was written in Braille, it could have been more understandable. Sometimes we may not perceive or find the shapes inside, so having a description of the embossed shapes would have been very explanatory.*

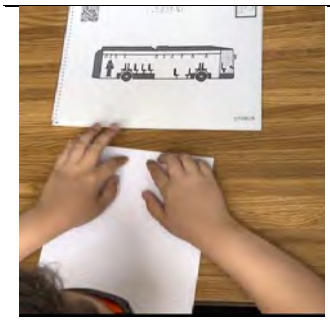
Initially, open the TIR application on the phone. Then place the phone in the holder on the table so that the phone's camera should be pointing downwards. Prepare the position of embossed/tactile concept image material on the table so that it is under the phone camera. Then hold your index finger on the embossed/tactile image or the QR code area in the top left corner

for 3 seconds. After hearing 3 beep sounds, the phone will describe the image aloud." (The phone is providing a verbal description of what the entire embossed/tactile image represents.) "After the description is finished, position your index finger to the part of the embossing where you want to hear the description and hold it steadily. For a detailed explanation of each part of the bus, navigate your index finger to the section and hold it steady, the application will describe the area you touched. When you said you finished investigation, I will start asking questions." (In this context, the student was provided with verbal cues initially, and then physical assistance when necessary while using the TIR application.) "Are you ready? I expect you to answer my questions honestly and think aloud"." The student was asked the same questions in asked first and second sessions after he finished the investigation. (see Table 3)

ASSESSMENT OF THE EXPERIENCE

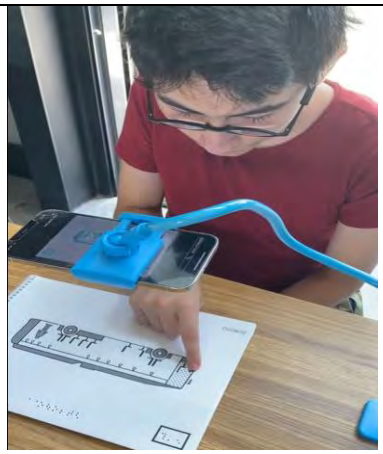
In the study, according to the answers received from the interview questions asked to the participants after each session, both the effectiveness of the learning processes with the Touch-Listen-Learn model and the students' learning were analyzed. During the learning process, the researchers did not provide any information related to the image. They only applied verbal hints and physical assistance when necessary while the participants were examining the embossed/tactile visual and engaging in the learning experience with the Touch-Listen-Learn model using the TIR

Table 2. Learning the Concept of Bus with Tactile/Embossed Visual and Written Description

Pictures of During Learning	Description of the Learning Process
	*S3, has read aloud the large print text related to the bus visual from the computer screen. The reading process was somewhat slow and occasionally mispronounced words. He completed his reading in a total of 72 seconds.* **Researcher:** *Could you show on the embossed/tactile concept paper the information about what you read?* *S3, navigated across the visual on the concept paper by touching each part without talking, just after reading. He pointed out the steering wheel in the visual.* **Researcher:** *Did support your learning when we gave both tactile/embossed visual and written descriptions?* **S3:** *The description was useful because it contained detailed information. There were more details in the description compared to the tactile. I couldn't understand the details very well when I touched it. But when I read with large print, I realized there were actually details there.*
	*S1 placed one hand at the beginning of the line and touched the lines with the right index finger, reading aloud and slowly.* S1 completed half of the text in 90 seconds. **Researcher:** *Could you show on the embossed/tactile concept paper the information about what you read with the braille description?* **S1:** *Yes, based on what I read in Braille, I think there is a steering wheel here in the picture. There are rings here, and there are seats. From here, there seems to be a standing passenger here as well.* **Researcher:** *When you compare the braille descriptive explanations related to the visual on the embossed/tactile concept paper, what would you say?* **S1:** *I preferred to examine the visual while the description was being made. When I first read and then examined the visual, I couldn't understand the parts in the figure. It might be better to have both the visual and description on the same page.*
	*S2 read quite slowly and by spelling, using the index finger of the right hand front the left hand.* The total reading time was 200 seconds. **Researcher:** *Could you show on the embossed/tactile concept paper the information about what you read with the braille description?* **S2:** *I can point to the steering wheel according to the braille explanations I read.* **Researcher:** *When you compare the braille descriptive explanations related to the visual on the embossed/tactile concept paper, what would you say?* **S2:** *Reading large print strains my eyes and causes headaches, and since I don't particularly enjoy reading braille, I prefer auditory descriptions. The Touch-Listen-Learn model made learning more enjoyable and effective for me by allowing me to understand the visual content through auditory description. So even someone who doesn't know braille can use it.*

application. According to the answers of the students after each session, it has been determined that the students learned the concept on the embossed/tactile concept image completely after the 3rd session. Additionally, feedback was received from the students suggesting that the large font size for low visions in the concept paper should be larger and bold. Also, the students stated that the braille and embossed lines should be higher, more noticeable, and readable. In the analysis of interview questions, it was revealed that all

Table 3. Learning the Concept of Bus with the Touch-Listen-Learn Model

Participants	Pictures of During Learning	Description of the Learning Process
S3 Student		**Researcher:** *You can examine the tactile concept paper; you should wait with your index finger steady on whatever part you want to learn.* *Participant S3 pointed to the image of a person inside the bus image and then the QR code by holding steady with his index finger.* **TIR:** *"There is a black representation of a person standing at the back of the bus. "* **Researcher:** *Did you think learning explanations about the bus visual on the embossed/tactile concept paper with the support of the TIR Application helped your learning? What would you say?* **S3***: Yes, that would be better. I would prefer the embossed/tactile visual provided with the mobile application over the bus visual given only with tactile and large print text. Because it vocalized the details one by one in a way I could understand smoothly. This is beneficial for me.*
S1 Student		**Researcher:** *You can examine the tactile concept paper; you should wait with your index finger steady on whatever part you want to learn.* *S1 places their index finger steadily on the seat in the bus visual to indicate it.* **TIR:** *There are nine seats for sitting inside the bus.* **Researcher:** *Did you think learning explanations about the bus visual on the embossed/tactile concept paper with the support of the TIR Application helped your learning? What would you say?* **S1:** *It is more beneficial because there is detailed information.*
S2 Student		**Researcher:** *You can examine the tactile concept paper; you should wait with your index finger steady on whatever part you want to learn.* *S2 places their index finger steadily on the QR code located in the upper left corner of the bus visual.* **TIR:** *The bus is positioned sideways, and its front is facing to the right. The inside of the bus is visible, and the doors and windows, which would be part of the outer frame, are not drawn.* **Researcher:** *Did you think learning explanations about the bus visual on the embossed/tactile concept paper with the support of the TIR Application helped your learning? What would you say?* **S2:** *The Touch-Listen-Learn method made learning more enjoyable and productive for me because it helped me understand the visual through auditory description.* *The descriptions my mom makes to help me at home are not clear, so even someone who doesn't know Braille can use it.*

three of the students participated in the study found that learning with the TIR mobile application-supported Touch-Listen-Learn model was an effective model and provided learning of large objects such as buses. It is very important for students with visual impairments to acquire information independently, as this ensures their education continues fluently. Also, they can access information at all times. The students with visual impairments who participated in the study mentioned that the Touch-Listen-Learn model enables individuals

with visual impairments to access visual content independently: “Touch-Listen-Learn is more accessible and more understandable, and I can understand visual information independently.” (S3).

Providing students with only tactile materials has ended in their incomplete and incorrect perception and interpretation of what they touch. For example, S1's comment about the first session is as follows: “If the description was written in braille, it could have been more understandable. Sometimes we may not perceive or find the shapes in images, so having a description of the embossed shapes would be very explanatory.”

According to feedback about the Touch-Listen-Learn model, the students stated that they generally find this model to be enjoyable and educational. Especially, due to describing each region of the visual separately, it has been determined that the Touch-Listen-Learn model helps to understand more details of the visual. S1 commented as follows: “Sometimes, I can't understand what the embosses/tactile represent. For instance, here, I couldn't figure out what the textured part was until the audio description mentioned the steering wheel.”

Furthermore, it has been determined that students with visual impairments who do not know braille can easily use this application offers the audio description provided by the Touch-Listen-Learn model. For example, S2 stated the following:

> Reading large print strains my eyes and causes headaches, and since I don't particularly enjoy reading braille, I prefer auditory descriptions. The Touch-Listen-Learn model made learning more enjoyable and effective for me by allowing me to understand the visual content through auditory description. So even someone who doesn't know braille can use it.

Based on the interview questions asked about the students' learning history, it has been revealed that students generally learn information through direct presentation and mental visualization. It has been stated that they do not use too many embossed/tactile materials either inside or outside the classroom. Students who use embossed/tactile materials in the classroom or at home state that they need help in understanding and using the material generally.

Additionally, students with visual impairments asked questions about the embossed/tactile concept before and after the application to evaluate their experiences of learning the bus concept through the Touch-Listen-Learn model. Before teaching, according to the question asked to the participants about what the embossed/tactile concept is, it was revealed that the participants had general knowledge about the bus concept but were not aware of the details related to the concept. The details regarding the participants' before and after training experiences related to the concept are provided in Table 4. Before the teaching, regarding what the concept is, participants provided very general answers such as "What I am touching is a bus because it is long like a bus and has seats." After the teaching experience, it was determined that participants acquired detailed information about the direction of the bus, its parts, and their locations (steering wheel, mirror, door, handles, etc.). They also learned what each part they touched was.

CONCLUSION and RECOMMENDATIONS

For students with visual impairments, sensory diversity is of significant importance in the concept-learning process (Kızılaslan & Sözbilir, 2018). In this study, a concept-learning experience was conducted for students with visual impairments, simultaneously providing tactile, auditory, and written descriptions. In order to facilitate the learning of the visual concept of a bus for the students, a series of activities were designed, as the following: initially, an embossed/tactile image; subsequently, descriptive braille and large print text in a digital form (for those with low vision) alongside the embossed/tactile image; and finally, an interactive technology-supported Touch-Listen-Learn model with image engagement. While doing the activities in this study, we were sure them one by one with each person, thinking about what each person is like and what they need.

At the beginning of the activity, students were asked questions about the concept they were going to learn. Their answers showed that they knew what a bus was in general, but they didn't

know its specific details. After the teaching was done, students were asked the same questions about the concept again. This time, they were able to give answers that included specific details about the bus. Although the participants had general knowledge related to the concept, it was seen that they acquired the details of the concept through the Touch-Listen-Learn model by the end of the learning process.

Table 4. Students' Experiences Regarding the Concept Before and After Bus Concept Teaching

		Pre-Teaching Experiences	Post-Teaching Experiences
Participants	**S1 Student** (Student Braille Reader)	**Researcher:** *I would like you to touch and explore the material in front of you until you understand it. Once you have finished examining it, please tell me what this embossed/tactile concept is, including all of its details.* **S1:** *This is a bus. There are seats in, it is long, and there are wheels. There are handholds that I touched. I had taken the bus before.*	**Researcher:** *Could you tell me all the details you have learned about the embossed/tactile concept that you have examined?* **S1:** *This is a bus. It has nine seats inside, wheels, and handholds hanging from the bus's roof. There is a steering area at the front of the bus. The bus door is at the front, near the steering wheel. A person is standing at the back of the bus.*
	S2 Student (Student Braille Reader)	**Researcher:** *I would like you to touch and explore the material in front of you until you understand it. Once you have finished examining it, please tell me what this embossed/tactile concept is, including all of its details.* **S2:** *It is a bus what I touched. There is a door here.*	**Researcher:** *Could you tell me all the details you have learned about the embossed/tactile concept that you have examined?* **S2:** *This is a concept of a bus. The bus's door is located at the front, where there is also the steering area, including the steering wheel. It has seats and handholds hanging from above. On the front side of the bus, there is a mirror positioned on the outside. At the back of the bus, there is a man standing. The bus is positioned sideways, and it has wheels.*
	S3 Student (Student with Low Vision)	**Researcher:** *I would like you to touch and explore the material in front of you until you understand it. Once you have finished examining it, please tell me what this embossed/tactile concept is, including all of its details.* **S3:** *It is a bus what I touched. Because it is long and has seats like a bus. There is a man inside the bus.*	**Researcher:** *Could you tell me all the details you have learned about the embossed/tactile concept that you have examined?* **S3:** *This is a bus. A person is standing at the back. The door is on the front side. Next to the door, on the outside of the bus, there is a mirror. There is a steering wheel at the front of the bus. Handholds are hanging from the roof of the bus. The side of the bus is visible, and it has wheels on its side. The front of the bus is towards the right.*

At the end of the application, it was observed that in sessions where only the embossed/tactile image was provided, the students were unable to perceive certain parts they touched with their fingers. They were unable to comment on the image. In the literature, it has been stated that one of the fundamental challenges students face in reading and interpreting tactile graphics is the nature of the graphics (such as swell embossed printing, thermoform 3D printing, etc.) and their design features (dot, line, texture, form, material, etc.) (Zebehazy & Wilton, 2014). Accordingly, it can be stated that the findings obtained from the study are consistent with the literature. In the second session, the description presented to students with visual impairments helped their understanding of the parts of the visual to a certain extent compared to the first session; however, it made it difficult for them to read and examine the parts of the embossed/tactile image related to the bus concept simultaneously. During the study process, the duration was extended because the students read the written description quite slowly and misread words at times. In the last session, the Touch-Listen-Learn model provided students with the opportunity to explore the image with both hands while simultaneously listening to audio descriptions throughout the learning process. It has been observed that the learning process with the Touch-Listen-Learn model, specifically the exploration of the embossed/tactile image, allowed students to acquire information in a

more independent, detailed, and enjoyable manner compared to previous sessions. Indeed, research has shown that materials combining tactile and auditory descriptions are more effective for individuals with visual impairments than only embossed/tactile materials. (Götzelmann, 2008; Melfi, et al. 2020).

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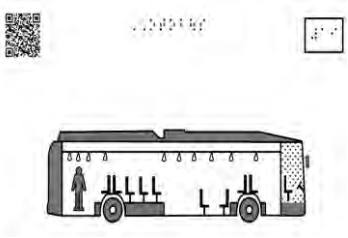
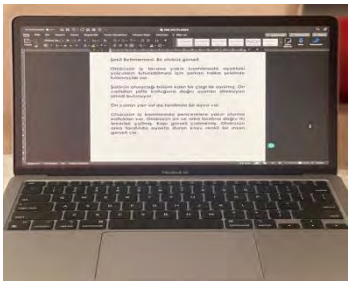
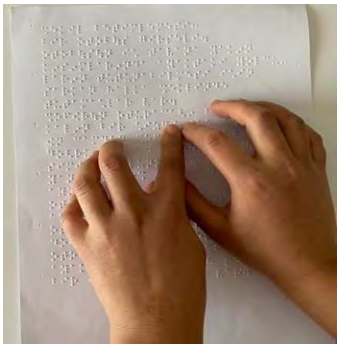
Appendix 1

Materials Used with the Touch-Listen-Learn Model

Name of Materials		Pictures of Materials	Descriptions of Materials
Tactile/Embossed Concept Visual Material			It is an embossed bus visual designed with epoxy print and labeled with a QR code. On this embossed/tactile concept paper, there is an embossed QR code for image description and the title of the material, page number in braille.
Tactile/Embossed Visual and Written Description	Large Print in Digital Platform		The visual of a bus from public transportation and its descriptions have been presented in a Microsoft Word document in digital format with 18-point bold font and in the Century Gothic font style.
	Braille		The visual of a bus from public transportation and the descriptions of its parts have been printed in braille without abbreviation.
Tactile Images Reader Mobil Application			The TIR application is downloaded for free from the App Store. The phone is placed in the phone holder, and the application is opened. By placing the embossed/tactile concept paper under the phone, interaction between the application and the material is facilitated. When the application detects the material, it will provide an auditory notification and will read out the general description of the visual. Subsequently, when you place your index finger steadily on the area of the visual where you want to get a description, after three beep sounds, it will vocalize the recorded descriptions for each area.