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'Everybody is sick and there won't be a cure': The Power of Privileging U.S. Student Voices through COVID-19 Drawings

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Abstract

The COVID-19 pandemic and the subsequent lockdown was particularly challenging for elementary students who experienced disruptions in almost all aspects of their daily activities. Our study addressed a dearth of U.S. studies documenting the adverse effects the pandemic created and continues to have for children by analyzing their drawings. This study was conducted post-lockdown after students resumed normal school operations. The Mosaic Approach framed this case study research that was conducted using drawings created by sixteen students in grades prekindergarten through fifth grade (ages 4 to 10 years old). Students drew what came to mind when thinking of COVID-19. We conducted a content analysis of the data and determined four dominant themes: (1) symptoms related to COVID-19, (2) evidence of psychological or emotional responses, (3) health and safety precautions, and (4) depictions of the virus cell. We assert children's drawings as a useful tool for educators to create opportunities to connect with students and potentially reduce their anxieties about issues, including those beyond the pandemic. This will be of interest to educators who may not have considered the power of children's drawings as a means to provide voice about current issues. It will also add to the global knowledge base about children's perceptions of COVID-19 and the resulting lockdown.

Keywords:

Children's Drawings, COVID-19, Social Emotional Support

Introduction

In this article, we explore the use of children's drawings as a means of communicating meaning assigned to the pandemic, a very confusing time for many school-aged children. First, we explore the existing global literature related to the pandemic, and then discuss children's drawings as a data source, which has long been used in the health care industry but is less prevalent in the educational community. Using the Mosaic Approach (Clark & Moss, 2001) to frame the study, we employed an adapted Draw and Write Technique (Pridmore & Bendelow, 1995) to analyze the drawings of sixteen participants in the United States, aged

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4-10 years old. Content analysis of the data revealed four overarching themes which included: Symptoms, Psychological, Health and safety precautions, and Virus cell depiction. We discuss the implications of providing drawing as a means for students to powerfully express their voice.

Literature Review

During the COVID-19 pandemic, researchers world-wide studied children's perceptions via their drawings. In Spain, researchers (e.g., González-Carlo, Varea, & García-Monge, 2022; Mondragon et al., 2022) investigated children's drawings about the lockdown and social distancing. Both studies found that children had major disruptions to their routines during lockdown that led to isolation, negatively impacting their social well-being. González-Calro et al. noted children reported they missed playing outside with their friends and visiting their grandparents the most. Mondragon et al. call for more attention to children's voices by placing greater emphasis on social and inclusive policies to alleviate possible effects of isolation during future lockdown situations. Cornaggia et al. (2021) conducted a similar study on children's drawings during the pandemic lockdown in Italy. In their study, children experienced tranquility and emotional well-being while spending time with family during the pandemic. However, children also expressed feelings of sadness and loneliness due to not being able to interact with their friends (Cornaggia). In France, in a study of children aged 5-17, researchers (Martinerie et al., 2021) found that children had relatively accurate depictions of COVID-19 and concluded that they had developed coping mechanisms for fears of COVID-19. Researchers in South Africa explored children's well-being and safety due to social isolation through drawings during the pandemic (Haffejee & Levine, 2020). In the United Kingdom, Bhandari (2021) explored areas of worry in children's drawings during the pandemic. Finally, in Sweden, Rydström et al. (2022) explored how children accessed and perceived information during the COVID-19 pandemic. Through all of these studies, it is evident that using children's drawings to illuminate the artist's perceptions of how they assign meaning to the world is useful. To our knowledge, very little research has been conducted in the United States. This study adds to this growing body of international research on children's drawings during the COVID-19 pandemic.

Children's Drawings as a Data Source

Drawing is a common activity for elementary children. What may appear to some as a simple by-product of passing time, to others it can offer a tool for unlocking children's communication about their worlds and the meanings they assign to these worlds. Children's drawings go well past the production of art, and instead, interweave their thoughts and emotions (Deguara, 2019), providing insights into children's way of thinking and how they make sense of the world around them. Drawing provides a child-centered approach to sharing those lived experiences that provide a window into a child's emotional and cognitive states (Bland, 2012; Mitchell, 2006; Zlateva, 2019). Drawing has been described as an effective means for children to reveal the complexities of their lived experiences (Mitchell, 2006; Walker, 2007) and is a natural way for children to express themselves without the typical filters of language. Children's drawings, however, are sometimes missed as a resourceful tool in understanding their social and emotional development in the elementary years. Children may be asked to draw as part of a formal lesson, for example a science lesson, or in lessons with the school's art teacher, but these drawings have a different focus. Such activities emphasize academic performance.

Children's drawings have been described as a means of gaining "informed insight" (Bradding & Horstman, 1999, p. 175), and are powerful tools for qualitative research, particularly when interpreted by the child instead of adults (Bradding & Horstman; Leonard, 2006; Günindi, 2015). Meanings are often attached to drawings and though sometimes more is drawn than can be described or translated into words, children can convey significant meaning to their drawings through writing or dictation (Dyson, 1986).

Several disciplines have used children's drawings in a variety of ways to better understand them. In education, children's drawings have been used to measure intelligence such as with the Draw-a-Person tests. In psychology, they have been used as therapeutic devices to access children's innermost feelings to assess their reactions to stress. In sociology, researchers have turned more frequently to the use of children's art as a means of visual communication (Leonard, 2006). In the field of health care, children's drawings have been used to reveal their perceptions of their own health issues and those of others (Bradding & Horstman, 1999), and their narratives offer valuable insights into children's wants and needs (Burgess et al., 2022).

Though certainly not universal, most children do seem to enjoy drawing and are considered competent in the activity (Leonard, 2006). Generally, drawing is viewed as an engaging, non-threatening and autonomous activity for children (Bradding & Horstman, 1999), while at the same time, it is also recognized as a reliable means to gather data (Zlateva, 2019). It is considered a developmentally appropriate means of collecting data with children as opposed to more common means of data collection such as surveys or interviews (Farmer et al., 2018). This study made use of children's drawings to better understand how they were making

sense of the COVID-19 virus post lockdown and upon reentry to school in 2022. Though the immediate threat of COVID-19 has significantly subsided, the information gleaned from these data provide important insight to educators and caregivers who continue to work with children who were indelibly marked by these events.

How Children Conceptualize Sickness

The health industry has long turned to children's drawings to better understand how children perceive illness. Children generally seem to categorize illness based on three characteristics or bodies of information: biomedical (e.g., the absence or presence of diseases); psychosocial (e.g., healthy people are happy and sick people are sad); and representations of healthy lifestyles (e.g., smoking is not a healthy lifestyle, but exercising is), (Mouratidi et al., 2015). Undoubtedly, a child's age plays an important factor in their perception of health and illness, and with increased maturity comes more complex, abstract, and scientific explanations of illness (Mouratidi).

Children's perceptions are shaped not only by their personal experiences and contexts of illness, but also by social context. Some research (e.g., Zaloudikova, 2010) suggests that children find it easier to define illness, which they typically see as a short-term condition, rather than health, which they typically view as a more permanent state.

Lasting Effects of COVID-19

In many aspects, the pandemic can be characterized as a trauma. Trauma describes those events that overwhelm a person's ability to adapt to life that leads to strong negative emotions that translate to perceptions of threat to self (Phelps & Sperry, 2020). Many facets of the COVID-19 pandemic and the lockdowns affected children and inflicted significant stress. Children's responses to trauma are largely determined by the surrounding adults' reactions and supports, as well as proximity to the traumatic event, and stability of the day-to- day routine (Fernandez, 2020). While many may believe that the pandemic is in the "rearview mirror," we assert that understanding children's perceptions of the COVID-19 virus is imperative to our current work with them in academic settings. Just because the threat of COVID-19 has subsided in most parts of the world, it is important to understand the lasting effects that COVID-19 may have on the mental, academic, and physical health of children, particularly as they are continually exposed to the news of emerging virus strands, new viruses such as Monkeypox, and continued attention and debate on immunizations and boosters. The effects of the pandemic, though still unraveling, are beginning to be documented.

Mental Health

For both children and adults, COVID-19 represents an interesting departure from many other forms of medical trauma. Even children who did not experience actual illness with COVID-19 often experienced anxiety, from mild to debilitating, about anything from contracting the illness (either themselves or a loved one) to interruptions of social time with their friends (Samji et al., 2022).

With the onset of the lockdown, social interactions and networks dissolved almost overnight and many children found this a devastating departure from their established support networks of peers and teachers (Pečja et al., 2021). Studies (e.g., Günindi, 2022) are beginning to document the ill-effects the lockdown had on socialization skills. In regard to mental health, children and adolescents are more likely to experience higher rates of depression and anxiety during and after periods of enforced isolation and this proved true following COVID-19 lockdown periods (Segre et al., 2021). Some research (Gupta & Jawanda, 2020) indicates that children reported increased anxiety and frustration about the future. There are clear associations between loneliness and mental health problems, mostly depression, even up to nine years later (Segre et al., 2021).

Other concerning findings from Günindi (2022) found that the pandemic adversely affected the social skills of preschool children, and that even though parents were able to spend more time with their children, these experiences were negatively overshadowed by worry over financial, health, and psychological issues, and decreased social and physical activities. At a time when children perhaps most needed the limited mental health services afforded to them in public schools, they were suspended due to school lockdowns.

Academic Health

Academic consequences from the pandemic are equally as concerning. Gupta and Jawanda (2020) summarize the negative effects on education as the following (p. 2): "Loss of quality, deprival of education, inadequate learning, lack of digital access, fall in educational outputs, wide learning gap between low and high socioeconomic group." Just as social networks were removed abruptly with the lockdown, so were established in-person pedagogies and peer learning opportunities (Kamei & Harriott, 2021). The pandemic and subsequent school closures and online learning disproportionately affected the academic development of vulnerable populations: students living in poverty, those requiring special learning services, and those who speak English as an additional language (Hoofman & Secord, 2021). I-mportant services were interrupted, and existing

challenges confounded. UNESCO (2020) indicates these devastating impacts hit low-income females the hardest, particularly in underdeveloped countries, as the risk increases for school drop-out, sexual exploitation, and early pregnancy.

Physical Health

Even though children were not as affected by the physical ailments of COVID-19 they are not free from impacts of the lockdown and the pandemic. Researchers (Gupta & Jawanda, 2020) express a variety of concerns related to physical wellbeing. These include the lack of outdoor space to which some children had access for physical activity, nutritional deficiency (particularly children who depend on school food programs), as well as routine health care visits that were often suspended as a result of overwhelmed health care facilities. They also point to negative effects that increased online learning at a computer may have on children, including back pain, eye strain, and insomnia.

Theoretical Framework

This study relies on the Mosaic Approach developed by Clark & Moss in 2001, which describes a strength-based approach for viewing children as experts in exploring and making meaning of their environments. It relies on positive, established relationships, and privileges active listening. Eskandari et al. (2021) denote that using the Mosaic Approach with children to understand their views can empower children to help shape their environment. The approach holds six key elements (Clark, 2017, p. 24), all of which were employed in this study. These elements include: multimethod, participatory, reflexive, adaptable, lived experiences, and embedded in practice (see Table 1).

Purpose of Current Study

The purpose of this study was to understand the perceptions of school-aged children (grades prekindergarten- fifth grade) about the COVID-19 through their drawings and dictations. We believed that by examining their drawings, we could gain a better sense of how children were processing these traumatic experiences, thus providing teachers and families with important insights as to how to help them cope. We note that the insights we gleaned apply to a specific snapshot in time, and that children continue to process, react, and reflect on their experiences.

Methods

We employed a variation of the draw-and-write technique, or DWT, (Pridmore & Bendelow, 1995), which came to prominence in the UK in the 1980s and became more popular around 2006 (Hartel et al., 2018). Known largely in association with the children's health care industry (Hartel et al.), the technique can assume many forms, but in essence, as the name suggests, involves the child drawing in response to a theme, topic, or research question, and the child (or an adult) writing down their associated ideas. Such a technique is effective because it recognizes the rights of children and views the child as the expert of their experiences and involves children as participants in the research, instead of just using them as objects of research (Horstman et al., 2008). This type of research answers the call for less intrusive, child-friendly methods of collecting data (Machenjedze, 2019). Understanding children's perceptions is paramount to improving the effectiveness of educational interventions. The DWT emphasizes the need for the child to feel valued, respected, and equal, at the end of the data collection (Horstman et al.).

Table 1

Elements of the Mosaic Approach in Study

Element	Characteristics of Mosaic Approach as Applied to Current Study
Multimethod	Recognizes different voices of children and creative strategies (Blaisdell, 2012). Students were free to draw their perceptions of COVID-19 without limitation. Children were viewed as collaborators in the study.
Participatory	Children are seen as experts in their own experiences and interpretations (Huser, 2015). No "right" or "wrong" determinations were made about their interpretations but rather appreciated as the child's reality.
Reflexive	Adults include the child's interpretation and reflect on that interpretation (Greenfield, 2011). Dictation was provided by the adult to explain the drawing, and both dictation and drawings informed results.
Adaptable	Can be applied in a variety of other settings (Clark & Moss, 2001). Children's drawings are recommended as a strategy for teachers in a variety of other settings
Lived experiences	Values lived experiences over knowledge (Rogers, 2020). As researchers, we were more interested in what children experienced as a result of COVID-19, instead of what they knew about the virus.
Embedded into practice	Listening framework that can be an evaluative tool and potential to be used in practice (Botsoglou, 2019).

Participants

The study was conducted with 16 participants in grades pre-kindergarten through fifth grade across the state of North Carolina. In the United States, these grade levels include children ages four to ten years old. We used convenience sampling based on adult students enrolled in a graduate early childhood education class, taught by the first author. Students enrolled in a Diverse Children and Families course were invited to submit children's drawings as part of a class assignment on children's understanding of the COVID-19 pandemic. Children who participated were family members and friends of the adult university students. Through the class, students were informed of the aims of the assignment and were reminded that submissions were purely voluntary and would not affect their grade in the class in any way. They were also reminded that the child, once asked to participate, could withdraw their participation at any time without consequence. Children who agreed to participate in the drawings were directed, "Draw me a picture of what you think about when you think of COVID-19." We encouraged the adults to provide little elaboration on the prompt and to allow children as much time as needed to complete the drawing. Upon completion of the picture, the adult or child wrote a verbatim caption of the drawing. Annotating children's expressions about their drawing is a practical way of gaining insight into what the child is focused on in their representation of a particular experience (Halpenny, 2021). Prior to submission, the adults were asked to include the child's current grade level. Some also included the child's age. The child's name and gender were not collected.

Drawings were collected during March 2022, at the late onset of COVID-19 as the lockdown was eased, and children returned to school, with the initial goal of the assignment being solely exploratory for the purposes of a graduate teacher preparation class. Based on the quality of the drawings, the descriptions, and the emergence of themes, the idea of analyzing the drawings as data surfaced. Parents were contacted again and asked if their child's drawing could be used for a research study. Thereafter, the second author joined the study and participated in all phases of the research. In March 2022, the omicron variant of COVID-19 was widespread across North Carolina and the United States (Fowler & Jasper, 2022). Although children had largely returned to in-person learning at school and state mask mandates had been lifted in February, COVID-19 remained a prominent issue on local and national news and in daily discourse both among families and the broader society.

Analysis of Drawings

We used content analysis to explore children's drawings and annotations of experiences related to COVID-19. Content analysis was chosen to analyze drawings because it keeps the participant's message as the focus rather than adults' interpretations (Merriman & Guerin, 2006). At the onset of data analysis, we independently reviewed the drawings and noted initial impressions of each picture. Next, we independently looked for and noted focal points of drawings such as situations, people, objects, and missing items (Halpenny, 2021). This led to our initial codes and categories. To ensure inter-rater reliability we analyzed the pictures and discussed our notes and initial impressions and focal points of the drawings together. Examples of codes included sickness, COVID-19 illustrations, precautions, emotional facial features, and personification. The codes were then grouped into four themes that are discussed below: (1) Symptoms, (2) Psychological, (3) Health and safety precautions, and (4) Virus cell depiction.

Results and Discussion

Analysis revealed four themes in children's drawings and depictions. Themes included Symptoms, Psychological, Health and safety precautions, and Virus cell depiction. Each theme is discussed below with supporting quotes and examples of children's drawings of each theme. While most drawings fit into one theme, some fit into multiple themes due to the content of the drawing and description.

Symptoms

Analysis of children's drawings and verbal descriptions indicated some drawings (n=7) centered on the symptoms related to COVID-19 such as coughing or sneezing. Some children spoke vaguely about "being sick" without discussing specific symptoms. For example, a child in first grade stated, "All the kids are sick." Another child in kindergarten stated, "COVID-19 is not good for people. It may cause passing germs and making people sick." Other children were more specific about symptoms in their depictions and drawings. One pre-kindergarten child shared, "COVID is cough. He got COVID because he was sneezing. COVID is not good." Interestingly, several children drew and described vomiting as a symptom of COVID-19. A pre-kindergarten child described COVID-19 symptoms by stating, "COVID is throwing up. It's like blue throw up. You can't breathe." Similarly, another pre-kindergarten child shared [Figure 1], "This is me throwing up. Vomit is coming through my teeth." We found this very interesting in that vomiting was not a common symptom of COVID-19. We wondered if some young children may automatically associate being "sick" with vomiting, particularly if this has been their own experience in the past.

Figure 1
You Can't Breathe

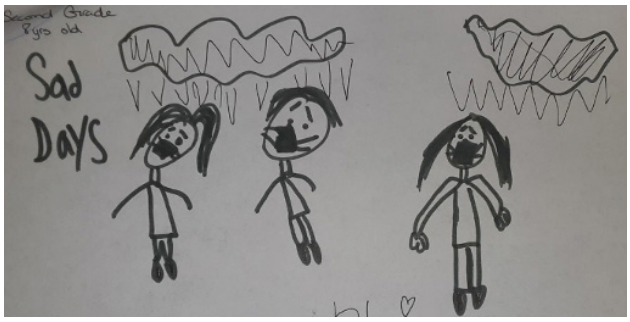
Finally, another pre-kindergarten child noted their drawing [Figure 2] shows, "My brother throwing up because he got sick. He was at school and got sick." Such statements are reflective of Chu et al.'s (2021) findings from research conducted with students aged 6-17 who were asked to write about their thoughts and feelings regarding COVID-19. Over 20% of the participants mentioned family concerns.

Figure 2
My Brother Throwing Up Because He Got Sick

Psychological

The Psychological theme captured drawings and/or verbal depictions with identifiable emotions or moods. This could be illustrated in the drawing of people or anthropomorphic characteristics given to the virus cell. They assigned psychological aspects to their drawings which included fear, death and destruction, clearly defined emotions and moods, and anthropomorphic features to the virus cell, often depicted as angry faces. For example, one second grader noted [Figure 3], "Sad days. Everybody is sick and there won't be a cure." The picture was drawn in black, which as Zlateva (2019) notes, can often be interpreted as a cry for help. While we do not know if the sole use of the black marker was intentionally or merely convenient, the limited use of color in this picture, and others from our data, are similar to Cornaggia et al.'s (2022) study of children's drawings of "Before" and "During" COVID-19 lockdown. In their study, children used less color in drawings of "During" lockdown than "Before" drawings. Mandrapa (2015) notes that children who feel anxious often include clouds, rain, and flying birds in their pictures. This was also found in Linder et al.'s (2017) study of drawings of children who are undergoing cancer treatment. Dark and stormy weather was associated with drawings that depicted "sick days."

Figure 3
Sad Days



In one first grader's drawing [Figure 4] the virus cell was drawn somewhat realistically and had an angry face above two people. The people were drawn with the letter "x" in place of their eyes. Zlateva (2019) indicates that the drawing of eyes is the most important detail of the face, and that closed eyes represent "a desire to hide from the world, avoiding visual contact" (p.92). We interpreted the teeth as an aggressive depiction, also confirmed by Zlateva. The fact that the faces are close together may suggest there is close communication between people (Edwards, 2016).

Figure 4
I Don't Like Covid

Two first graders drew pictures of people dying (although they did not specifically say they died from COVID-19). Finally, one fifth grader captioned their picture, "Coronavirus destroying a plant." In their picture [Figure 5], the cell is depicted with slanted eyebrows and something orange dispelled from the mouth. This picture also denotes the bold strokes drawn close together that are associated with stress, strong feelings, and even anger (Mandrapa, 2015).

Figure 5
Coronavirus Destroying A Plant

This stood out to us as a psychological trait given the anthropomorphic features and the use of the word "destroy."

Reminiscent of this study, other studies (Martinerie et al., 2021; McGellen et al. 2021) have explored children's drawings of COVID-19 and found them to include anthropomorphic features in the virus cell. They note how this can be from the messaging they receive through media or news. In studies that have examined children's drawings related to the COVID-19 pandemic, other researchers have also found children include clear emotions in their drawings. In Thompson, Spencer, and Curtis' (2021) study on children's perspectives on COVID-19 within the United Kingdom found fear and sadness to be a primary theme of their findings. Children in their study reported being scared of getting the virus, anxiety over loved ones dying, and an abrupt change to their daily lives. Undoubtedly, COVID-19 elicits strong emotions in children which may continue to be conjured when discussed or heard on the news.

Health and Safety Precautions

The third theme, Health and Safety Precautions, included drawings and/or verbal depictions specific to the public messaging during the pandemic. Five drawings and descriptions illustrated specific precautions related to the pandemic including wearing masks, social distancing and lockdown procedures, and getting vaccinated. One fourth grader said, "Going to school, but have to wear a mask." In the picture [Figure 6], the child labeled the person "me" and added, "mask to be safe." Another fourth grader drew a picture [Figure 7] of a mask and a needle, adding the caption, "My picture is a shot and mask. You should always wear your mask. You should get the vaccine which is the needle shot."

Figure 6
Going to School But Have to Wear A Mask

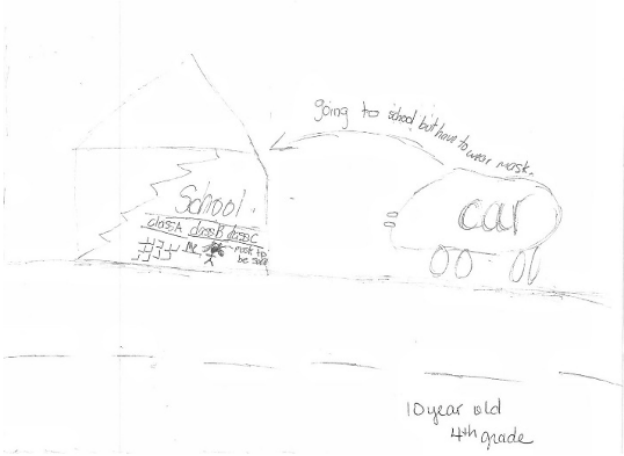
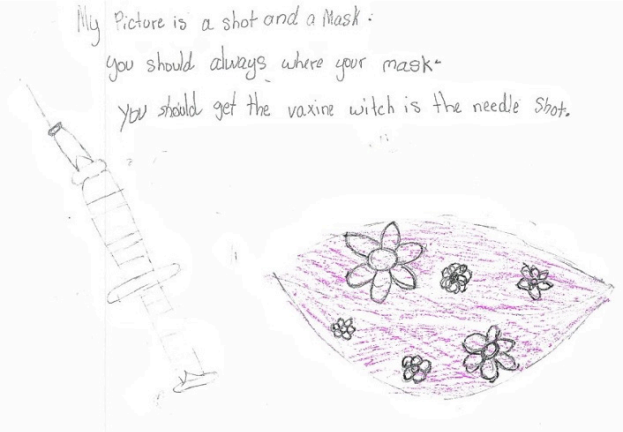


Image 7
A Shot And A Mask



Finally, a pre-kindergarten child also drew a picture of masks and noted, "You wear a mask so you don't get COVID-19. You have to go to the store and buy stuff and stay home." We found it interesting that in all sixteen drawings, no child drew a picture of handwashing. We speculated that children may have been more exposed to this heath habit, and thus did not mention it because it was less novel than wearing masks, social distancing, or isolating.

Virus Cell Depiction

The Virus Cell Depiction theme included drawings that had a representation of the actual coronavirus cell that was circulated widely in the media. It is recognized as a gray spherical mass with red triangle-tipped spikes. Several children included their interpretations of the virus cell with a sphere and protruding spikes. For example, Figure 8 illustrates a fifth grader's representation of COVID-19, with a caption that reads, "COVID spreading COVID."

Figure 8
COVID Spreading COVID

These findings are supported by other studies (e.g., Bonoti et al., 2022; Joubert & Wasserman, 2020) in which children illustrated an accurate understanding of the virus cell. This has been attributed to the abundance of information and pictures shared via the news, social media, and health and safety resources (Bonoti et al., 2022). While access to information is helpful, it may also cause additional stress to children who are also processing the overwhelming amount of information or do not have an understanding of molecular cells.

Limitations

Despite the interesting findings of this study, there are a few limitations that should be noted. For example, because we imposed the research questions after the drawings were collected, we had no influence as to the exact methods used to initiate the drawings. Had we been present for the drawing activity, and known this would lead to research, we would have asked the children additional questions and recorded longer responses to elicit additional context around their assigned meanings. Additionally, we had little to no knowledge as to the drawing materials provided to children for their drawings. This became particularly relevant as we reviewed pictures drawn with one or limited colors and wondered if this held any significance. Research (e.g., Farolkhi & Hashemi, 2011) suggests that the dark shading of face or body is correlated with both anxiety and depression, as is the choice of dark over light color choices. Not knowing if the color choice was intentional or merely based on available materials meant that we could not draw such conclusions.

Future studies may also wish to more closely note the ages of the artists, as developmental maturity is expected around age 7. As children become more mature in their understanding of biology, it reasons that their conceptualizations of COVID-19 may also be affected. Some research (e.g., Cornaggia, 2022) suggests that older children are more expressive in their drawing. More research is needed, however, as there are also studies (e.g., Bonoti et al., 2022) that suggest age-related themes are not dominant, and that children of all ages produce images with common characteristics.

Implications and Conclusions

This study reaffirms the use of children's drawings as a legitimate data source. We conducted the study to shed light on the perceptions children held about COVID-19 in a way that went deeper than simply asking them to respond verbally to questions. In so doing, we were able to determine common themes that were important to students. We offer this method as a resourceful tool for teachers and families to gain insights into the perceptions of children, particularly when they may not have the vocabulary to properly convey their thinking. Through drawing, children create an important entre to their way of thinking that can provide a trusted adult the opportunity to ask additional questions and clarifications. These windows into a child's thinking provides adults valuable information as to how to better equip them to cope with stressful and anxiety-producing situations. In fact, Kang et al. (2020) suggest art as a specific strategy for mitigating anxiety in children. For example, adults may be able to offer clear explanations about misconceptions, or simply provide additional emotional support, that otherwise may have been missed. Kang et al. report that fear of the unknown is particularly worrisome for children, and thus it serves children well to create opportunities for conversation in age-appropriate terms and increases their trust in the caregivers. While the pandemic may be less threatening now than at the time of this study, there is still a preponderance of situations and events that elicit anxiety in children (and adults). We assert that teachers can use times throughout the day as appropriate, to offer drawing opportunities for students, in order to gauge student well-being. The findings of this study demonstrate the impact that COVID-19 had on children, particularly

the negative associations with the lockdown, illness, and even death. While we may not know the impact this anxiety and negativity will have on children, it does send an important message that it is up to us, as adults, to continue to ask children how they are processing such information.

This study amplifies the need to continue to monitor public messaging. Many children repeated the messaging of wearing masks, getting vaccines, and maintaining social distance. Such findings indicate that public messaging (and perhaps parental reinforcement of this messaging) was effective, and has impacted children, who felt they knew what strategies to adopt to keep safe. It is important to continue public messaging in ways that are appropriate for both children and adults, as it is apparent that children do in fact internalize this messaging.

For researchers, the collection of children's drawings centered on a global pandemic creates a unique opportunity for cross-cultural analysis of children's lived experiences and perceptions. The COVID-19 pandemic created universal experiences across the globe including, but not limited to, possible illness, social isolation, and psychological distress including fear, anxiety, and post-traumatic stress. Examining children's drawings of their experiences during the pandemic allows researchers to compare across cultures during a given time frame. Given the handful of studies that examined children's drawings from the pandemic, there appears to be representation across the globe.

Because of this study, we more fully appreciate the power of drawing and dictation to provide children voice as to how they are interpreting their worlds. Discussions of drawings serve as an inviting way to involve students in sharing their thinking and is less intrusive than asking incessant questions in conversation. Drawings and focused dictations, though certainly not a replacement for other therapeutical strategies, can help empower even young students and provide adults with better understandings of the supports children need as they make sense of their world. One key takeaway from this study is that children are often eager to share their perceptions and understandings through drawing, so as adults, we would be remiss not to use this as a tool for increasing our capability to assist them.

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Teaching the First Component of Social Referencing to Preschoolers with Autism; Reacting to New and Missing Objects in the Environment

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Abstract

Deficits in social referencing have been associated with autism spectrum disorder. It may lead to deficits in language, symbolic abilities, and other social-cognitive behaviors. When deficits in social referencing are detected, teaching such behaviors should be a priority, but effective teaching procedures are lacking. We consider social referencing as a behavior chain and suggest teaching each component in the chain in sequence. We introduce a program to teach the initial component of social referencing, reacting to new and missing objects in the environment through initiating interaction with another present person. Six children with autism spectrum disorder participated. All children acquired the skill within six months and generalized it to new people and materials. Future research could aim to replicate these findings and to develop effective procedures to teach other component skills of social referencing.

Keywords:

Social Referencing, ASD, Behavior Chain.

Introduction

Social impairments are addressed in most comprehensive intervention approaches, but it has proven difficult to produce substantial improvements (Kasari & Patterson, 2012). Social referencing is described as "a process in which one person utilizes another person's interpretation of the situation to formulate his or her own interpretation of it" (Feinman, 1992). In other words, this includes obtaining information about how to react in an ambiguous novel situation and adjusting one's behavior accordingly. Lubomirska et al. (2021) found that typically developing children, when exposed to three emotional scenarios (fear, pain, and joy), look at the other person for cues before taking any action. Children with ASD, in contrast, were found to show little or no social referencing behavior when exposed to the same three scenarios (Lubomirska et al., 2021).

In behavior analytic terms, social referencing behavior can be considered a behavioral cusp as it has importance for many aspects of development, such as creating

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secure attachment (Feinman, 1992), learning how to communicate with tone of voice, gestures, eye contact and facial expressions (Every Child a Talker; ECAT, National Strategies). Social referencing may be viewed as a behavior chain (Gewirtz & Peláez-Nogueras, 1992). Each link or component in the chain is both a conditioned reinforcer for the previous response and a discriminative stimulus for the next response (DeQuinzio et al., 2016). The chain starts when a child is exposed to an ambiguous novel stimulus (e.g., an unfamiliar adult or situation). This is a discriminative stimulus for referencing another present person. This in turn becomes a discriminative stimulus for a response from the referenced person. The response from the other person is the presentation of a verbal and /or non-verbal cue to the child. This serves as a discriminative stimulus for a child's next response, approaching or avoiding the ambiguous stimulus, depending on the cue from the other person.

Teaching social skills such as responding to and initiating joint attention, which is the „simultaneous engagement of two or more individuals in mental focus on one and the same external thing" (Holth, 2005; Kasari & Patterson, 2012) is often part of early intervention programs. There are also studies focused on teaching some components of social referencing, for example, responding to the affective behavior of others (Argott et al., 2017), discriminating facial expressions (DeQuinzio et al., 2020) and learning empathy skills (Sivaraman, 2017). We found only one study where an attempt was made to teach the whole chain of social referencing to children with ASD (Brim et al., 2009).

Looking more closely at social referencing, we can say that the chain consists of two links, in which there are two primary responses of the child: observing in the first link and either an approach or avoidance in the second link. An entire social referencing sequence begins when a child is exposed to an ambiguous novel stimulus (e.g., an unfamiliar adult or a new object). This is a stimulus evoking an observing response in the child (the child looks at the other present person, e.g., the mother). The discriminative stimulus for the child's response is the cue/affective display presented by the other present person (e.g., smiling, frowning, head nodding, head shaking), which begins the second link of the chain. The cue is both the conditioned reinforcer (learned in the past through pairing with primary reinforcer) for the observing response as well as the discriminative stimulus evoking the subsequent response of the child (approach or avoidance; in this case to interact or not with the stranger). Observing is reinforced only in the presence of ambiguous stimuli, while in the presence of unambiguous or standard stimuli it is not reinforced. Thus, observing will occur more frequently in the presence of ambiguous stimuli and less frequently in the presence of non-ambiguous stimuli. Certain classes of cues/affective stimuli (smiling, head nodding, and pointing) signal approach, frowning, fearful expressions, or head shaking signal avoidance (Gewirtz & Peláez-Nogueras, 1992).

Brim et al. (2009) perceives social referencing as "seeking out discriminative stimuli provided by others about contingencies in an ambiguous context in order to respond in a manner that produces reinforcement". These "discriminative stimuli provided by others" are affective displays, presented by the present familiar person (Gewirtz & Peláez-Nogueras, 1992).

The social referencing chain consists of several skills: the ability to recognize ambiguous stimulus, the ability to focus on the face of the other person, the ability to discriminate facial expressions, and the ability to adjust one's behavior based on what was observed. Brim et al. (2009) targeted the entire social referencing chain, teaching their participants an observing response and discriminative control of ambiguous situations using adult affective reactions to children's responses. To teach the ability to differentiate between usual and unusual ambiguous stimuli, the children were faced with multiple sets of stimuli. In Brim's study (2009) these stimuli were variants of standard task materials (e.g., paper bag as a writing surface, word to imitate presented with a cough and a model wearing an animal mask in a motor imitation task). The presence of the ambiguous stimuli was followed by one of two affective discriminative stimuli: a smile and head nod or a frown and head shake. In the presence of the smile and head nod, task completion was reinforced. In the presence of the frown and head shake, termination of the task was reinforced. All four participants learned to complete or terminate the task depending on the affective display of the experimenter. However, only one of the participants learned to discriminate between ambiguous and non-ambiguous situations.

The difference between social referencing and joint attention is that initiations are only reinforced in the presence of ambiguous, such as novel or missing objects or people. In the present study we wanted to expand on the very first steps of Brim's study and teach children to react to ambiguous stimuli by initiating interaction with another person present.

Method

Participants

The participants were five boys and one girl with autism, aged between 3 and 5 years (see Table 1 for more details). The diagnosis of autism was based on ICD-10 criteria (World Health Organization, 1996) and was made by a multidisciplinary team of independent specialists (psychologist, special educator, and child psychiatrist). All the children presented persistent deficits in social communication

and social interaction across multiple contexts and restricted, repetitive patterns of behavior, interests, and/or activities (American Psychiatric Association, 2013). Their developmental age, based on the Psycho-Educational Profile-Revised (PEP-R; Schopler et al., 1990), varied from 1 year and 3 months to 4 years and 5 months (see Table 1).

Table 1
Description of Participants

	Gender	Chronological age	Developmental age	Language level
Participant 1	Boy	5:0	4:5	Sentences
Participant 2	Girl	3:0	2:0	Single words
Participant 3	Boy	3:8	3:1	Sentences
Participant 4	Boy	3:8	1:5	Single words
Participant 5	Boy	4:8	2:8	Single words
Participants 6	Boy	4:2	1:3	Single words

Generally, the most significant deficits were in the areas of imitation, receptive language, expressive language, and fine motor skills. All participants demonstrated limitations in spontaneous language and social initiation.

Setting

The present intervention was conducted across four locations: (1) in a typical classroom furnished with desks, chairs and bookcases with toys and books; (2) in a corridor with bookcases, desks with computers and toys; (3) in a school bathroom; (4) in a lunchroom furnished with tables and chairs and with a row of sinks on one of the walls. During teaching, other children and teachers were at times present in the classroom, corridor, or lunchroom.

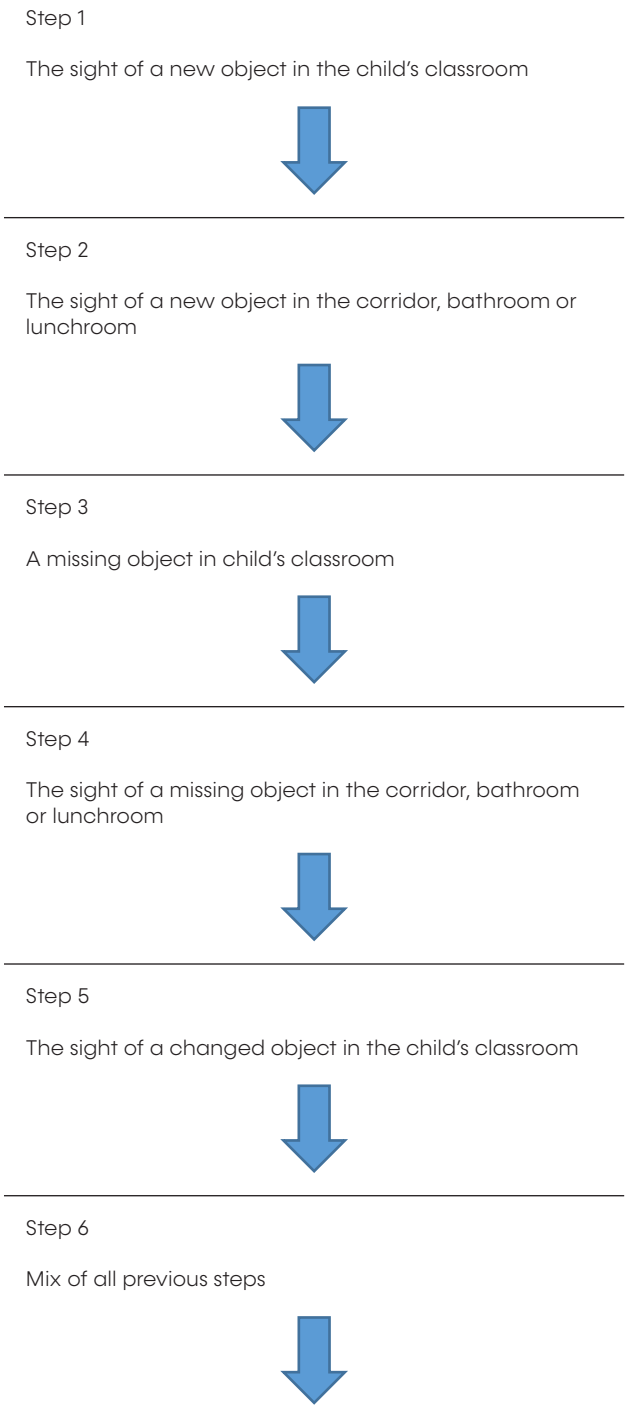
Response definition

Response definition. Initiation was defined as saying "look" to another person while having eye contact, at the sight of a novel or missing object. This statement had to be separated from previous vocalizations by a change of topic or change of person to whom the interaction was directed. The child's statement was followed by teacher's explaining the situation and providing an opportunity to touch the object if it was a novel object in the environment.

Procedure

Social referencing teaching steps. The intervention was divided into several steps, and each step had to be mastered before the child was moved on to the next. There were six steps in the program (see Figure 1).

Figure 1



Step 1 was to initiate interaction by saying "look" while having eye contact with the teacher at the sight of a new object in the child's classroom; step 2 was the same but it was conducted in the corridor, bathroom and lunchroom; step 3 and 4 was identical to steps 1 and 2 except that the object now was removed; step 5 was identical to steps 1 and 2 except that the object was changed and step 6 was a mix of all the previous steps. We did not teach discriminating between initiating at the sight of a novel or missing object and initiating at the sight of objects that were already in the environment. The reason was that if

a child with ASD initiates interaction at the sight of the known object in the environment, it would be a desirable behavior (initiating joint attention). However, our records show that none of the participants did this during the project.

Generalization. Generalization sessions were held in all settings where teaching was conducted, but with teachers who did not take part in teaching and with materials that where not used during teaching. During generalization trials prompts, feedback and rewards were not provided.

Evaluators. The teachers conducted all the teaching sessions and evaluated the children's interactions and did all the probes. There were six teachers, four psychologists and two special educators, all of whom had at least two years of training in behavior analysis and worked daily under the supervision of an Ph.D. level behavior analyst with 15 years of experience working with people with ASD.

Intervention

To teach initiating interaction with the teacher, we used manual prompts (Cooper et al., 2020) and a script-fading procedure (McClannahan & Krantz, 2005). Manual prompts were used to teach children to point to the new object in the environment or to the place where an object was missing. Manual prompts were defined as manual assistance to display the desired response. Prompts were faded in frequency and intensity as rapidly as possible. For some participants we begun with hand-over-hand prompts, then moved to spatial fading and increased the distance to the child. The fading of prompts depended on previous experience with the individual child in other tasks.

We used a one-word script in the form of auditory prompts on a recording device (Mini Me; Krantz & McClannahan, 1993, 1998) that modeled the appropriate language. During fading, we first removed the recording and only the sight of the device served as a prompt; then we removed the device entirely.

During intervention for step 1, the teacher went with the child outside his classroom and left him for a while under the supervision of another adult. She then returned to the classroom and placed a big, colorful object on the child's chair or desk. There were three objects prepared beforehand and hidden during the day for this purpose. In step 2 these objects were placed on the floor in the corridor, in the sink in the bathroom and on a desk or chair in the lunchroom. After placing the object, the teacher walked with the child to this place, so that the child could easily notice it and then used manual prompts to have the child point to the object and say "look". A correct initiation was reinforced with praise and snack and access to the object. When an object was missing, the correct initiation was reinforced with praise and snack only. Additionally, the teacher commented and explained the situation.

During the teaching the child was prevented from making incorrect responses through prompts that were provided when the child did not initiate the interaction or tried to initiate it with an inappropriate script.

Data collection

Baseline. Baseline consisted of testing all steps in the intervention. During baseline no reinforcements, prompts or feedback were provided.

Pretest. Before each step was introduced, a pretest specific to that step was conducted. The pretest for each step was the same as that conducted in baseline, including the test for generalization. Generalization sessions were held across all settings, with different objects and with people who had not participated in the intervention. Data were collected every 10 days and graphed as a percentage of correct responses. During data collection the conditions were identical to teaching sessions, except that no prompts were delivered. A step was considered mastered if the child responded correctly in at least 80% of the trials either in the pretest or during consecutive data collection.

Inter-rater agreement

The inter-rater agreement was calculated using unweighted kappa (Landis & Koch, 1977) and assessed at least twice for each of the participants, during the pretest and during the end of the intervention. Inter-rater agreement ranged between 0.8 and 1.0 (considered high).

Results

All participants scored 0% correct for all steps in baseline. All the participants mastered steps 1 through 6 (i.e., reacting to new and missing objects in the environment) within seven months of training. All of them learned to initiate appropriately in response to missing objects and novel objects across whole variety of settings. There were variations in how much training was required (see Table 2 – 7).

Participant 1 scored 0% correct in the pretest and in the generalization test in step 1. After 30 days he achieved mastery of step 1. In step 2 his scores in the pretest and the generalization test were 30% correct and 20% correct, respectively. He met the mastery criterion after 20 days. In step 3 he started off with 70% correct in the pretest and mastery in the generalization test. He mastered the step after 10 days of teaching. Steps 4 and 5 and 6 were all mastered in the pretest.

Table 2

Number of days in which mastery of each step was achieved - Participant 1

														Day
Step 6	Mix steps 1-5											100*	100	
Step 5	Initiating interaction at sight of changed object in the child's classroom									100*	100			
Step 4	Initiating interaction at sight of the missing object in the corridor, toilet or lunchroom							100*	100					
Step 3	Initiating interaction at sight of the missing object in child's classroom					100*	90							60
						70	80							
Step 2	Initiating interaction at sight of the new object in the corridor, toilet or lunchroom			100*	100									50
				70										40
				30	20									
Step 1	Initiating interaction at sight of new object classroom	80*	90											30
		50												20
		40												10
		0	0											0
	Baseline all steps	0	0	0	0	0	0	0	0	0	0	0	0	3
		0	0	0	0	0	0	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	1
		Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	

Note. *Criterion for mastery met, Gen: = Generalization probes across people and material.

Table 3

Number of days in which mastery of each step was achieved - Participant 2

														Day
Step 6	Mix steps 1-5											90*	90	
Step 5	Initiating interaction at sight of changed object in the child's classroom									90*	100			
Step 4	Initiating interaction at sight of the missing object in the corridor, toilet or lunchroom							100*	100					70
								70	70					
Step 3	Initiating interaction at sight of the missing object in child's classroom					100*	100							60
						60	70							
Step 2	Initiating interaction at sight of the new object in the corridor, toilet or lunchroom			100*	90									50
				70										40
				50	40									
Step 1	Initiating interaction at sight of new object classroom	100*	100											30
		60												20
		30												10
		30	20											0
	Baseline all steps	0	0	0	0	0	0	0	0	0	0	0	0	3
		0	0	0	0	0	0	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	1
		Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	

Note. *Criterion for mastery met, Gen: = Generalization probes across people and material.

Table 4

Number of days in which mastery of each step was achieved - Participant 3

																Day
Step 6	Mix steps 1-5													100*	100	
Step 5	Initiating interaction at sight of changed object in the child's classroom											90*	90			90
Step 4	Initiating interaction at sight of the missing object in the corridor, toilet or lunchroom							80*	90							80
Step 3	Initiating interaction at sight of the missing object in child's classroom					100*	100									70
						50	60									
Step 2	Initiating interaction at sight of the new object in the corridor, toilet or lunchroom			90*	90											60
				60												50
				30	30											
Step 1	Initiating interaction at sight of new object classroom	100*	90													40
		70														30
		50														20
		20														10
		10	10													0
	Baseline all steps	0	0	0	0	0	0	0	0	0	0	0	0			3
		0	0	0	0	0	0	0	0	0	0	0	0			2
		0	0	0	0	0	0	0	0	0	0	0	0			1
		Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.			

Note. *Criterion for mastery met, Gen: = Generalization probes across people and material.

Table 5

Number of days in which mastery of each step was achieved - Participant 4

																Day
Step 6	Mix steps 1-5													90*	80	
Step 5	Initiating interaction at sight of changed object in the child's classroom											90*	90			140
												60				130
												50	60			
Step 4	Initiating interaction at sight of the missing object in the corridor, toilet or lunchroom							100*	100							120
								70								110
								50								100
								30	30							
Step 3	Initiating interaction at sight of the missing object in child's classroom					100*	90									90
						70										80
						40										70
						30	20									
Step 2	Initiating interaction at sight of the new object in the corridor, toilet or lunchroom			100*	80											30
				60												50
				40												40
				10	10											
Step 1	Initiating interaction at sight of new object classroom	90*	90													30
		60														20
		30														10
		0	0													0
	Baseline all steps	0	0	0	0	0	0	0	0	0	0	0	0			3
		0	0	0	0	0	0	0	0	0	0	0	0			2
		0	0	0	0	0	0	0	0	0	0	0	0			1
		Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.			

Note. *Criterion for mastery met, Gen: = Generalization probes across people and material.

Table 6

Number of days in which mastery of each step was achieved - Participant 5

															Day
Step 6	Mix steps 1-5												90*	90	
Step 5	Initiating interaction at sight of changed object in the child's classroom									100*	100				170
										70					160
										70	70				
Step 4	Initiating interaction at sight of the missing object in the corridor, toilet or lunchroom							100*	90						150
								70							140
								60	50						
Step 3	Initiating interaction at sight of the missing object in child's classroom					90*	90								130
						70									120
						60									110
						60									100
						40	40								
Step 2	Initiating interaction at the sight of the new object in corridor, toilet or lunchroom			80*	80										90
				70											80
				50											70
				30											60
				10	10										
Step 1	Initiating interaction at sight of the new object classroom	90*	80												50
		70													40
		50													30
		40													20
		20													10
		0	0												0
	Baseline all steps	0	0	0	0	0	0	0	0	0	0	0	0		3
		0	0	0	0	0	0	0	0	0	0	0	0		2
		0	0	0	0	0	0	0	0	0	0	0	0		1
*Criterion for mastery met		Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.		

Note. *Criterion for mastery met, Gen: = Generalization probes across people and material.

Table 7

Number of days in which mastery of each step was achieved - Participant 6

															Day
Step 6	Mix steps 1-5												80*	90	
Step 5	Initiating interaction at sight of changed object in the child's classroom									100*	100				180
										70					170
										60	70				
Step 4	Initiating interaction at sight of the missing object in the corridor, toilet or lunchroom							100*	100						160
								70							150
								50							140
								40	40						
Step 3	Initiating interaction at sight of the missing object in child's classroom					100*	90								130
						70									120
						60									110
						40									100
						20	10								
Step 2	Initiating interaction at the sight of the new object in corridor, toilet or lunchroom			80*	90										90
				70											80
				50											70
				30											60
				0	0										
Step 1	Initiating interaction at sight of the new object classroom	90*	80												50
		70													40
		50													30
		40													20
		20													10
		0	0												0
	Baseline all steps	0	0	0	0	0	0	0	0	0	0	0	0		3
		0	0	0	0	0	0	0	0	0	0	0	0		2
		0	0	0	0	0	0	0	0	0	0	0	0		1
		Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.	Probes	Gen.		

Note. *Criterion for mastery met, Gen: = Generalization probes across people and material.

Participant 2 scored 30% correct in the pretest and 20% correct in the generalization test in step 1. He met the criterion for mastery after 30 days of teaching. In step 2 he started off with 50% correct in the pretest and 40% correct in the generalization test and mastered the step after 20 days of teaching. In step 3, he scored 60% correct in the pretest and 70% correct in the generalization test and met the criterion for mastery after 10 days. In step 4 he started off with 70% correct for both the pretest and the generalization test and needed 10 days to master the step. Both step 5 and 6 were mastered in the pretest.

Participant 3 started with 10% correct in the pretest and in the generalization test for step 1. He needed 40 days to master this step. In step 2 he scored 30% correct in both the pretest and the generalization test and mastered it within 20 days. In step 3 he scored 50% correct and 60% correct in the pretest and the generalization test, respectively, and met the criterion for mastery after 10 days. Steps 4, 5 and 6 were all mastered in the pretest.

Participant 4 scored 0% correct in the pretest and in the generalization test in step 1. He achieved mastery in 30 days. In step 2, he scored 10% correct in both the pretest and in the generalization test and achieved the criterion after 30 days. In step 3, he started off with 30% correct in the pretest and 20% correct in the generalization test and mastered the step after 30 days. In step 4 he scored 30% correct in both the pretest and in the generalization test and mastered the step after 30 days. In step 5 he started off with 50% correct and 60% correct in the pretest and in the generalization test, respectively. He mastered this step within 20 days of teaching. Step 6 was mastered in the pretest.

Participant 5 scored 0% correct in the pretest and in generalization test in step 1 and met the criterion for mastery after 50 days of teaching. In step 2 he started off with 10% correct for both the pretest and generalization test and mastered the step after 40 days. In step 3 he scored 40% correct in both the pretest and the generalization test and met the criterion after 40 days of teaching. Step 4 started with 60% correct in the pretest and 50% correct in the generalization test, and he needed 20 days to master the step. In step 5 he scored 70% correct in both the pretest and the generalization test and mastered the step within 10 days. Like all the other participants, he mastered step 6 in the pretest.

Participant 6 started off with 0% correct in the pretest and generalization test for step 1 and needed 50 days to master this step. In step 2 he scored 0% correct in both the pretest and the generalization test and mastered it in 40 days. In step 3 he scored 20% correct and 10% correct in the pretest and generalization test, respectively, and met the criterion after 40 days. In step 4 he scored 40% correct in both the pretest and generalization test and mastered the step within 30 days. In step 5 he started off with 60% correct in the pretest and 70% correct in generalization test and mastered the step after 20 days of teaching. Step 6 was mastered in the pretest (see Tables 2 – 7).

Discussion

In this study we taught 6 children with ASD to react to ambiguous stimuli such as new and missing objects in the environment. All the participants learned to notice objects that were new or that were missing, and to initiate interaction with the teacher. The interaction consisted of pointing to the object or to where the missing objects were supposed to be, looking at the teacher and saying "look". This skill generalized across different materials and different people. It is important to note that all the participants had previously mastered how to make eye contact in different situations and react to their names.

These results show that it is possible to teach adequate reactions to ambiguity in the environment. Such a reaction is considered the first component of the social referencing behavior chain. However, for social referencing we need to add the next steps, focusing on the face of the other person, discriminating facial expressions, and adjusting one's behavior based on what is observed. Future studies will have to explore if these can also be taught.

While curricula for young children with ASD include teaching programs from many different domains (e.g., matching, imitating, receptive language, expressive language, etc.) there appears to be a lack of empirically supported programs for teaching social skills, which constitute probably the most complex and serious deficiency. However, several conceptual and empirical papers have been published on teaching social behaviors, including joint attention skills (Holth, 2005), responding to the affective behavior of others (Argott et al., 2017) and teaching empathy (Sivaraman, 2017; Sivaraman et al., 2022). Our results from evaluating typical children's social referencing skills with the SoROS suggest that typical children will look at the person displaying an emotion and act based on the cues provided. If this is the normal pattern of behavior, this can serve as a model for what should be taught.

This study has several limitations. The data represent only a small group of children. All of them were young, so we do not know if these results could be replicated with older children. During the intervention period, the participants were taught several other skills as part of their program. The impact of learning these otherskills is not known.

New objects to which the participants were taught to react, were attractive to them, and the consequence

of initiating the interaction after noticing this object was the possibility to play with it. We don't know if children would make initiations if the objects were less preferred. The range of places in which reacting to new objects was trained was also limited. Another limitation is the lack of experimental control. We collected data every 10 days of teaching, but the design does not allow us to rule out alternative explanations, such as maturity, or the child learning other language skills.

Because all teachers work under regular supervision, during which they are observed and assessed for procedural integrity, we did not measure this specifically for the procedures employed in the current study.

In future research, it will be important to test this program in a larger and more diverse group of children with autism, e.g., different ages, different levels of cognitive functioning and expressive language. It should also be evaluated if teaching more complex initiations affects the duration of the learning process.

One area for future research could also be to teach the steps using a sufficient exemplar training format. This may make it easier to individualize teaching and pinpoint exactly when a step is mastered,

Future studies should also focus on developing other components of social referencing, such as learning to focus on the face of the other person, learning to discriminate facial expressions and, finally, learning to adjust one's behavior to the cues provided. All these skills will need to be taught to children with ASD for them to properly reference other people.

Based on our research, we have some promising indications that the first component skill in social referencing can be taught, and that the skill may be generalized across persons and materials. This is a promising start for developing the entire sequence of social referencing behavior. With a clearly described program and sequence of introduction, one of the most important behavioral deficits in children with ASD may be addressed.

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Engagement in At-Risk Students Trajectories: Perspective From The Levels of Approach To The Student

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Abstract

Student engagement within education has been an area of increasing interest over recent years as one of the factors that needs to be taken into consideration when addressing one of the main issues in education - school dropout. The objective of this paper is to provide oversight of how being engaged in the educational trajectories of young people who are at risk takes place. This will involve applying the theory of life course as the main driver of the research. A qualitative method is used which adopts a biographical and narrative approach via semi structured in-depth interviews. The main results have revealed that: 1) there are stages in which events that facilitate positive or negative engagement are more predominant; 2) generally, there are more negative critical events that result in a decline in the quality of student engagement; 3) there are several factors that stand out in each of the stages of the student trajectories.

Keywords:

Engagement, Educational Trajectories, Narrative Inquiry, Life History, Life Course Theory

Introduction

There are many issues within education that are rooted in history. Some have extensive research behind them and therefore provide additional detail (Garnica et al., 2019). This is relevant to the problem tackled within this study, that of the school dropout rate of vulnerable, also known as at risk, students (Bernárdez-Gómez et al., 2021; Thureau, 2018; Vandekinderen et al., 2018) and how these students can then return to their studies (Cuconato et al., 2017; Tomaszewska-Pękała et al., 2017; Portela et al., 2022; Ribaya, 2011). This text presents some of the results of a wider research project where the factors that do or do not benefit school engagement of young dropouts and returnees are examined. Therefore, the aim of the research was to determine the various factors intervening in student engagement via these stages of young people's educational trajectories when they have dropped out of school.

This research examines the circumstances of those who have been prioritised for education administrations over the years and in spite of this still demonstrate their relevance. The obsolete Europe 2020 Strategy to the current

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Sustainable Development Goals or the Horizon Europe Framework Programme (EU Regulation, 2021) proposed goals which could be aimed at enhancing educational quality and well-being in schools. Consequently, those organisations are referred to by us as OECD (Viac & Fraser, 2020), and we can say that wellbeing in educational centres therefore has a direct link to educational quality provided by the school system. Therefore, it should be demonstrated how the challenge can no longer be used to retain valuable students, but instead to determine friendly spaces within the centres where studies can be performed, and engagement maintained throughout the educational trajectories.

Educational trajectorias and Life Course Theory

Studying educational trajectories is based on studying the life courses of the individuals (Hutchison, 2019; Monarca, 2017). This is a popular theory used within the field of social sciences and has increased in relevance to research within the social sciences (Tomaszewska-Pekala et al., 2017; Mena, Fernández & Enguita, 2010). Development of the paradigm on which life course theory (LCT) has been developed is multifactorial in nature, as is the dropout problem. The various factors that can be found within their past research are consistent (Bernárdez-Gómez, 2022; Gottfried & Hutt, 2019). Therefore, using the life course theory, events are presented that have a significant effect on the trajectory of students. These events are the factors which have been found by authors including Salvà-Mut, Oliver Trobat & Comas Forgas (2014) or Nichol, DeFosset, Perry & Kuo (2016), who have referred to various spheres of proximity to the individual: micro, meso and macrosocial. Simultaneously there are different events that can occur which have a different intensity. First, life events present throughout the whole trajectory but yet have no particular significance for the subjects (Kang, 2019; Tarabini, 2018). Conversely, there are critical events, which are powerful enough to stimulate a transition within the trajectory that lead to a change in their direction.

The various events that happen within an individual trajectory have a significant effect on the resultant implications (Crosnoe & Benner, 2016; Vicente & Gabari, 2019). One frequently occurring definition of the idea of engagement is that student attachment exhibits within their studies and affects the intensity with which they are dedicated to a specific educational task (Emery et al., 2020). In this instance, when various events lead to deterioration in student engagement, this ignites a process of disengagement (Yusof et al., 2018). At this point the situation is being referred to in which a student begins a gradual withdrawal from the educational experience provided by the school (Gebel & Heineck, 2019). Therefore, the various data that have been extracted from the research will demonstrate the types of engagement that more frequently occur within the trajectories of dropout students. The stages whereby students present more positive or negative engagement are also presented. Finally, events are identified that produce quality of engagement either in a positive or negative direction.

Engagement in students´trajectories

Student engagement, as a construct reflecting the link with school student tasks has been much examined over recent years (Cooley et al., 2021). These studies have begun to question how the teaching and learning process has developed based on a school's history, academic life, and characteristics that result from students (Boyaci, 2019; Mayhew et al., 2016; Teuscher & Marakova, 2018). One of the main researchers in this area is Astin, who defined student involvement as the amount of energy that a student invests in the educational experience (Astin, 1984, 1993). This energy, which is modulated by the learning process, places us in terms of quality (Zabalza & Zabalza Cerdeiriña, 2022) within a process that can be understood as a continuous phenomenon passed through by the individual.

The concept of non-involvement or low quality of it within students manifests within the literature as an abstract issue within any field (Bernárdez-Gómez, 2022). Therefore, it is a heterogeneous phenomenon for which there is very little agreement of the mobilisation, hanging, internal or virtual absenteeism, or lack of belonging or affiliation (Fernández Enguita, 2011). The intersection of all of these aspects is the final project of moving away from common concepts between students and schools and the removal of the feeling of belonging (Tomaszewska-Pekala et al., 2017; Mena, Fernández & Enguita, 2010). This causes us to reflect on the distinction between schools and students and the potential dichotomy between students who acted in a way that was initiated towards the institution, and those who present with problems. Consequently, it is an issue that affects all students, and which has several levels of intensity, different means, and different results. These results have traditionally resulted from the situations of the students within a risk context.

Trajectories of vulnerable students

Risk at school affects students who, because they are vulnerable, "suffer learning difficulties with some severity in the educational systems, centres and classrooms we have" (Escudero & González, 2013, p. 13). Students at risk who experience difficulties in their education are not uncommon and the phenomenon is often seen as an epidemic in the education system (Karacabey & Boyaci, 2018; Rogers, 2021). This makes it ripe for further investigation.

From a wider perspective, the subjects who find themselves in a situation of risk are those who "due to certain personal characteristics and perhaps a set of them, as well as social, community and family, have high probabilities of reaching undesirable results by being exposed to the influence of situations and contexts of risk" (Escudero & González, 2013, p. 20). It is important to note from this definition how the subjects, in spite of their singularities, are subject to a large influence by the realities in which they are framed, and stay as the ones that will promote, or not, situations of risk (Barros, Souza Neto, Silva, & Guedes, 2019). Similarly, these students are those who go on to have the highest likelihood of absenteeism, abandonment, and school failure (Jurado & Tejada, 2019; Rubio, 2017) as well as undesirable results and insufficient skills to integrate into patterns of society, family, and working life (González & San Fabián, 2018). This results from a danger of the individual not developing their potential because of the risk situations which can go onto affect their educational career.

Method

Design

Considering this study's objectives and the previous research that has been conducted on this issue (Deterding & Waters, 2021), this study was conducted using a qualitative approach. In particular, the design had a biographical-narrative nature. By developing this type of methodology, we were able to establish the various events that occur during the student trajectories (Brandenburg, 2021) with the aim of gathering and understanding the various relationships that can develop over the course of a life (Rodríguez-Dorans & Jacobs, 2020). This methodology therefore tries to make sense of and build meaning from individual events that, via the researcher, are then evoked in the individuals (Portela et al., 2019, 2022). This involves using a reflective and introspective process of the individual and contrasting the different events that have occurred within their life or in regard to an aspect of their life.

Data collection

The data collection method was used to conduct research on life histories using semi-structured in-depth interviews. This has been determined as one of the best approaches to carry out biographical-narrative research (Rodríguez-Dorans & Jacobs, 2020) as it allows the researcher to be immersed within the issue and be flexible enough to develop the interviews according to the different needs as they arise (Deterding & Waters, 2021). The individual aggregate method was used to validate the interviews (Traverso, 2019) by producing an initial draught and gaining feedback from field experts. The interviews were structured to have three sections, one was a series of initial questions so that the researcher could verify that the interviewee was suitable for this study and to establish the personal and socio-humanitarian context from which they come. Second, a central block was dedicated to investigating each stage of the student's career: the stage prior to leaving school, the stage at which they were away from the school, and the stage of reincorporation. Lastly, a block of questions were aimed to investigate the aspects that were unclear and assess their trajectory as well as their prospects.

Sample

The sample was chosen on a non-probabilistic purposive basis. There were three criteria used for selecting the individuals: a) young people that had been away from school and, subsequently; b) they were at the moment of their participation involved in studying some of the measures aimed to foster their reincorporation into the educational system; c) the size of the sample. This final factor was the most relevant, as twice as many people were chosen as recommended by Hernández-Sampieri, Fernández y Baptista (2018) for this research, from three to five individuals. Lastly, the sample consisted of 10 people from programmes which were deemed to be encouraging people back into training. In particular, four comprised of basic professional training, four of professional training programmes, and two of entrance exams. The characteristics of these types of reinstatement programmes were specifically for "students at risk of educational exclusion and/or which feature personal characteristics or schooling background which result in a negative appraisal of the school framework" (Bernárdez et al., 2021, p. 257). Thus, it is guaranteed that one of the candidate requirements is that they have been through a situation of distance and reincorporation into the school.

Data analysis

Qualitative data analysis was performed using two complementary techniques: content analysis (Friese, 2020) and Barton & Lazarsfeld's qualitative data analysis model (in Taylor et al., 2015). Using these two techniques sequentially was done with the support of the analysis software ATLAS.ti. First, a content analysis was performed, whereby: 1) the information was reduced, and the data was prepared for coding; 2) the data was structured through categorisation and; 3) relationships between the different categories were extracted. Second, the process was complemented by the model of analysis as described by Barton &

Lazarsfeld (1961): 4) systematising the relationships via code concurrences; 5) making matrix formulations using semantic networks and; 6) conducting a theory-supporting analysis.

The benefits of using qualitative analysis by Barton and Lazarsfeld (1961) was pointed out by Glasser & Strauss (1967) who described it in analysis that could be conducted using this procedure on both a simple and more complex level. Using this procedure has meant there is greater relevance to using this process via support from data analysis software such as ATLAS.ti (Friese, 2020). Software helps with monitoring the analytic steps by using tools that help with each stage, as in previous research (Bernárdez, González & Rodírguez, 2022; Bernárdez, Portela, Nieto & Rodríguez, 2022), and which are described below.

The categories used in the analysis can be seen in table 1. Within which we can highlight the categories that are related to student involvement as perceived by them, the event type, the stage in their educational trajectories in which the event takes place, and the type of event depending on the approach of the student.

Results and Discussion

Trajectories of the students were analysed and reconstructed, and each has demonstrated the uniqueness of an individual to whom the story belongs. In terms of this paper, we aim to focus on how engagement is located within these life stories and also how engagement is manifested within the quality of the stories and within each of the trajectory stages. Conversely, the main events in the student trajectories and their relationship with engagement quality will also be reflected.

Engagement in students' trajectories

First, when we focus on how engagement is reflected in each of the events of the subjects, we can assess that there is a likelihood of an event tending towards a negative nature (Figure 1). In both of their critical events there is a greater importance for the subject and in their life events, everyday events, as well as a greater connection with events that lead to a provocation of negative engagement. Yet, if we are only to focus on life events there can be no difference between the events that lead to the student distancing themselves or the level of engagement with their studies. Cooccurrence coefficients[1] of 0.57 and 0.47 are presented, which have a small difference in this aspect. Conversely, there is an observed substantial difference between positive and negative critical events, with negative events occurring most frequently. This reveals that in the trajectory of the individuals, events tend to push them towards leaving school. This is the result of the

Table 1.
Codes and groups of codes used in the analysis.

Level of student approach		Engagement type	Stages in educational trajectory	
Macrosocial	-Education and training system -Dominant social values -Links between training and employment	-Positive Engagement -Negative Engagement	Previous primary stage	Stage away
Mesosocial	-Community -Family -Peer group -Educational centre	Life course theory -Life events -Critical events	Previous secondary stage	Reinstatement stage
Microsocial	-Individual characteristics -Interpersonal relationships		Distancing stage	Timeless

events being decisive in the direction that they take students in terms of their career, with seven points of difference in their co-occurrence coefficient and their quintuplicate number of events.

Figure 1.
Co-occurrence between types of events and different qualities of engagement

	Negative_Engagement 451	Positive_Engagement 379
CRITICAL EVENTS 53	47 (0,10)	11 (0,03)
LIFE EVENTS 811	457 (0,57)	382 (0,47)

Moreover, if we only focus on identifying at which point the events are concentrated according to their positive or negative engagement, we are then only able to highlight two differentiated aspects (Figure 2). The events which have the highest negative engagement occur in the stages prior to the student leaving their studies. Specifically, there is an outstanding co-occurrence coefficient (0.48) in the stage before the dropout happens. This could be over the result of progression between the stages before the dropout occurs, as the quantity of negative events multiplies, while the quantity of positive events is unchanged. This accords with the events that develop a positive engagement, the majority of which happened within the re-entry stage, with a significantly higher co-occurrence coefficient than in the other stages.

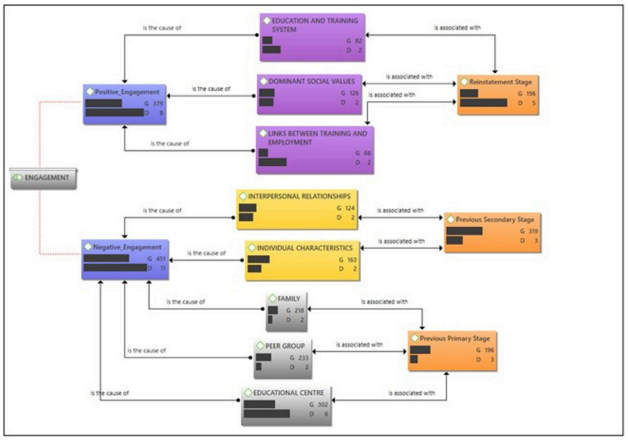
Figure 2.
Co-occurrence between different engagement qualities and stages of the trajectories.

	Negative_Engagement 451	Positive_Engagement 379
Previous Primary Stage 196	123 (0,23)	86 (0,18)
Previous Secondary Stage 319	248 (0,48)	86 (0,14)
Reinstatement Stage 196	43 (0,07)	165 (0,40)
Stage away 95	48 (0,10)	52 (0,12)

The factors that emerge according to the quality of engagement

As previously mentioned, there are some stages in student trajectories that differ from others because of engagement quality in terms of events that occur within them. Thus, the presence of different factors within the stages is heterogenous. In every stage of the different subjects there is event diversity that refers to a number of different factors affecting the school trajectory, however, there are many factors that predominate over others within every stage. These factors are illustrated in figure 3.

Figure 3.
Semantic network[2] of the relationship between quality of engagement, factors and stages of the trajectory.



The semantic network that emerges from these co-occurrences, which we have found between the factors in the various stages, are reflected in table 4. The network is created in terms of different events occurring in each stage and whether the events lead to a positive or negative engagement.

Table 4.
Cooccurrences between types of events present in the trajectories and each of the stages they pass through.

	Previous primary stage		Previous secondary stage		Stage away		Reinstatement stage	
	No. quote	CooC	No. quote	CooC	No. quote	CooC	No. quote	CooC
Individual characteristics	11	0.03	49	0.11	26	0.11	51	0.17
Interpersonal relationships	27	0.09	64	0.17	10	0.05	7	0.02
Community	19	0.08	26	0.08	8	0.06	6	0.03
Family	70	0.20	65	0.14	31	0.11	50	0.14
Peer group	59	0.16	139	0.34	25	0.08	18	0.04
Teachers	54	0.16	79	0.19	20	0.08	44	0.13
Educational centre	99	0.25	157	0.34	17	0.04	57	0.13
Education and training system	5	0.02	23	0.06	11	0.07	37	0.15
Dominant social values	17	0.06	31	0.07	25	0.13	54	0.20
Links between training and employment	4	0.02	8	0.02	22	0.16	39	0.17

Note. Extracted from data analysis in ATLAS.ti.

Mesosocial factors, influence of the family and its relationship with the center and peers. In the initial stage which occurred before the students left their primary or secondary school, there was a decrease in engagement quality which resulted from factors which were close to the experience of the students. These school related events, as well as those related to family and peer groups, stand out particularly within primary education although they do not have a high co-occurrence coefficient, nor did they have an especially high number of citations. As seen from the student quotations, the relationship with each group is especially relevant. In fact, there is a presence that defines the trajectory of the students who are at risk of exclusion.

> *It helped me because I used to say to dad, I don't understand this, can you help me, but maybe he didn't come to help me and that, I don't know... it bothers me because from childhood to adolescence, he doesn't ask me: - hey, what's wrong with you? (D3:35)*[3]

> *I remember one of them very fondly, one in particular who was my tutor in class. [...] The man must have retired years ago, he was older, he was a good guy, he was a constant source of laughter (D1:41)*

When addressing each factor individually in terms of the dimensions of the meso social level, we find that a difficulty occurs specifically in terms of the analysis and the breadth of factors that comprise each dimension. Beginning with those that demonstrate less relevance in terms of student trajectory and those referring to the community, it can be seen that there is anecdotal evidence indicating a low relevance for students in terms of this factor (Ribaya, 2011). This may also show that there is a limited influence in the stage before the distance when the subjects have stated that the environment in which they are developing their studies and which highlights how harmful this can be to their studies as a result of the environment being too distant from the school culture (Salvà-Mut et al., 2014).

If we adhere to the order that determines the relevance of events according to the quantity of appearances that appear in the coding, then the family is presented as a dimension that takes its significance from an influence on how the life stories of students are configured. Thus, throughout every stage there is a continual presence of events which are related to it, whereby attending to circumstances lends a trivial cohesion towards the family nucleus (Garnica et al., 2019). This includes the excessive responsibility of students with roles to which they do not belong, at least because of age, or little involvement from the family (Tarabini, 2018) in their children's education and, by extension, in what happens in school.

Conversely, the group of equals is also relevant primarily in the stage before abandonment, which is a stage associated with student friendship and which is significantly influential (Cooley et al., 2021; Salvà-Mut et al., 2014). The primary events showing a student's stories are linked to those which derive from students and that have a lower educational level and problematic behaviours than those that distance themselves from school and their education.

Lastly, at the mesosocial level, the school is the primary dimension generating the events influencing student trajectories. It is therefore important for schools in terms of student educational trajectories that factors comprising this dimension are relevant to the lives of students within a psychosocial context.

Microsocial factors, interpersonal relationships and individual characteristics. At the secondary education stage there is a similar phenomenon, with micro social factors having an increasing relevance in terms of individual characteristics and relationships. Upon reaching adolescence they have already begun a stage in that development where the events closest to them have not increased in importance. How they handle their personal characteristics and the influences on them from their closest circle of friends will be decisive in how they develop their trajectory and when the most negative events happen.

> *Mathematics has always been very difficult for me, I see a number and I don't know what to do with it. (D2:48)*

> *There are teachers who have given me many opportunities, of course, who have helped me [...] and they are good people who have been very good to me (D5:54)*

Conversely, the stage when they are away is not representative of a specifically significant stage for the student. Although they do start to have a sense of how macrosocial factors influence their trajectory and in a more significant way. In this way, via the quote we are seeing an example of how dominant social values influence student trajectories when they have moved away from education.

> *I was ashamed to be asked or that we were among us, talking in the group of friends at home and, maybe, we would talk about it: at seven euros an hour for six days 7×6... and I would stay, oh my God, don't ask me. (D9:44)*

Among the various factors at the microsocial level are examples of event diversity that also affect student trajectories. If individual characteristics are considered (Monarca, 2017), then issues of security and self-esteem as well as behavioural issues become externalised, including a delinquency or aggression that develop internally as well as depressive states (Kang, 2019). According to Salvà-Mut et al. (2014),

these difficulties influence how a school provides feedback to students when a significant number of them are only referring to the negative experiences experienced during their school time (Boyaci, 2019; Teuscher and Makarova, 2018) because of issues such as low participation or not having a sense of belonging, or a lack of academic skills and learning ability. There may also be issues of educational support needs (Yusof et al., 2018). Yet those events that are related to the interpersonal relationships of students also have a greater significance as well as being a hindrance to them, because they are deeply connected to events linked to their own individual characteristics. This is because whilst there is an absence of valuable and relevant relationships in both older students and their teachers, there will always be a lack of reference for generating positive experiences in their core where they feel that sense of belonging that is often lacking.

Macrosocial factors, dominant social values and the employment training system. Lastly, and more positively, student engagement is presented as being an improvement during their re-entry phase. Events that are related to the dominant social values as well as the relationship between training and employment or specific training lead to a significant increase in engagement. At this stage students see the importance of training because of interventions that are not within their control. This results in them assuming that they are unable to intervene and that it is necessary that they should just align themselves with the issue.

> *They didn't think so much about you, it's like university, you know? ... Simply: I'll give it to you (professors giving the homework) if you like it, fine, if you don't like it, if you don't like it at all, get a life, that's it, I wash my hands of it like Pilate. In VET they give you the opportunity to meet, to say: I like this, I'm going to do this. And above all, they are looking out for you. (D2:62)*

> *Because I need a job, and I need to try to pick up everything else, to learn everything I haven't learnt. (D5:83)*

Various events that can be found are reflected in the quotations from the macro social level and the factors affecting the stages of the educational trajectories within the previous levels. This is because many reflect on the actions that are conducted by a person or an individual level as a direct result of culture and society that they are involved in (Fernández Sierra, 2017; Jimenez, 2008; Salvà-Mut et al., 2014). These are the primary sources from which macro social factors emerge.

One example of this is dimension that is related to the educational system. Although within life stories events of different programmes and measures are aimed at alleviating the issue discussed, there remain legislative issues towards what happens within schools. These events can make it impossible to devise any improvements or changes at a particular level and therefore these are barriers of a structural nature.

Another factor that has a basis in every level is that of dominant social values. We know that students take on a self-image based on preconceived ideological patterns (Barros et al., 2019; Karacabey and Boyaci, 2018). This danger results in the assumption of a future eventuality that belongs to a specific ethnic group, that of growing up in a specific environment where there is little value placed on education or that the culture does not place a particular value on education. Given this issue, there is a fear that this problem lies within a foundation that is both diffuse and global.

Conversely, although there is no strong link with other levels of all dimensions, there is a referral to the relationship between training and employment which manifests mainly in reintegrating students into the educational system. The main reason is that the perception is that subjects developed their training and positioning as a form of motivation that helps them to access the job market and presupposes improvements within the expectations they have of the labour market. A major incentive in training is that it is employment orientated, and the subjects therefore assume that they have taken the correct path. Yet, this high level of involvement demonstrates that there was a singularity that takes an extensive amount of time to emerge and which leads us to question why, before leaving school, there is a lack of awareness of this specific need.

Conclusions

The apex point of the students examined here is the end product of slowly distancing themselves from the common ideas of the school and moving away from a feeling of belonging and engagement with the school (Emery et al., 2020). Similarly, this distance is again lowered by the students being re-involved in their studies through various factors producing the same effect. This results in us reflecting on the separation between a student's school and a potential dichotomy between these units in accordance with the institution and those who are presenting with problems. Therefore, it is a phenomenon affecting every student and which has multiple levels of intensity and results (Salvà-Mut et al., 2014). Likewise, it is also a process that is very expressive of the student's boredom with their school and with the schools having both outdated and rigid (Nichol et al., 2016; Yusof et al., 2018) teaching methodologies which manifest as tedious and irrelevant for the student's education.

The various events occurring in each student's school career are neither episodic nor are they disconnected from one another (Christodoulou et al. 2018). Plus, the aim of constructing their life history is an attempt towards understanding the continuities, events, and

experiences happening within a school's trajectories and how they divert and establish the twists and turns in student lives and passage through school (Gebel & Heineck, 2019; Hutchison, 2019).

The emergent school trajectories have, more or less, been reflected in the various trajectory models used as a reference (Cuconato et al., 2017; Tomaszewska-Pękała et al., 2017). However, there are specific differences between the emerging patterns and those used as a reference which reveal that the trajectory models are more sharply focused on processes of absenteeism; dropping out of school does not fully chart the trajectory of someone returning to training. Yet, Blasbichler & Vogt (2020) state that student perspectives have their own course life, even though their trajectory develops in a specific direction, as they are both dynamic and reversible. They do this by using their own resilience, whereby the situation in which they find themselves is corrected and after which they are unaffected. Finally, and in line with the objective set, there are various manifestations of student engagement which are strongly tied to different career stages. This is because of the strong relationship between various factors and specific quality of engagement. There are also factors facilitating student involvement and other factors that facilitate their distance. Similarly, it was also verified that, in each trajectory stage, there are factors in which its presence is predominant.

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Ethics

This research has been approved by the research ethics commission of the University of Murcia (Id: 3226/2021)

Footnotes

1. Co-occurrence coefficients are offered by the ATLAS.ti software from the relationship strength between two codes.

2. In the semantic network, in addition to the different relationships between codes, we will find the total number of citations of a code (letter G) and the relationships with other codes that have been established for that code (letter D).

3. For the citation of the material, the coding offered by the analysis software has been used, where the D indicates the interview number, and the next number indicates the citation within that document.

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Preservice Elementary Teachers' Understanding of Fraction Multiplication and Division in Multiple Contexts

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Abstract

The present study examined preservice elementary teachers' performance on the problems of multiplication and division of fractions and compared their performances and analyzed the misconceptions. An instrument including 11 fraction multiplication and division tasks was given and the task involved three contexts: making own story problem, computations, representing operation using visual model. The findings reported that among the three contexts, making a diagram was the most challenging task for both operations, and their division performance varied depending on the division problem types. The author suggests that specific emphasis with rich story problem with different whole(s) in fraction, carefully designed context with different types of division concept, and building fractional number sense can help both PSTs and students reduce misconceptions and enhance deeper understanding of fraction operations.

Keywords:

Teacher Education in Elementary Mathematics Education, Teacher Education, Preservice Teachers' Learning Mathematics

Introduction

The pivotal role of real-world contexts and visual representations in teaching fractions are outlined in policy and recommendation documents (e.g., National Council of Teachers of Mathematics [NCTM], 2014; Common Core State Standards Initiatives [CCSSI] 2010). Despite of the importance of this concept, the struggle with teaching and learning fractions has been an ongoing issue for in-service teachers, pre-service teachers (PSTs), and elementary students (Newton, 2008; Park, 2013). Unfortunately, elementary teachers' knowledge of fractions is often weak (Ball 1990a; Ma, 1999; Park, 2013) and deficiencies in fraction knowledge continue to exist for both preservice and in-service teachers (Ma, 1999). In particular, the multiplication and division of fractions are known for being the least understood and the most mechanical topic in elementary school mathematics (Izsák, 2008; Tirosh, 2000).

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These studies document PSTs' lack of conceptual understanding of multiplication and division with fractions and address how conceptual understanding is critical for their future students. For instance, without a deep understanding of the concepts, their students cannot reproduce meaningful instruction of fraction division (Ma, 1999), and teachers' knowledge often predicts students' achievement gains (Newton, 2008). Iskenderoglu (2018) emphasized that if we want the students to have conceptual understanding of fractions, we need to prepare PSTs to have robust conceptual understanding first.

Then, how can we support preservice teachers? The present study aims to make some suggestions for teacher educators through exploring elementary preservice teachers' conceptual understanding of fraction multiplication and division. This content area was a focus because fraction multiplication and division is a critical component of elementary school mathematics that relates to students' learning algebra and rational numbers in the later grades (Ball, 1990a; Luo, Lo & Leu, 2011). In addition, research studies continuously report preservice teachers lack conceptual understanding in this area (Lou et al., 2011; Ma 1999; Son & Lee 2016; Tirosh 2000; Tirosh & Graeber, 1990). The goal of this study is to first assess PST's performances in multiplication and division of fractions in various contexts and identify and analyze most common difficulties on the tasks. The three contexts are creating story problems, solving real-world application problems, and visually representing the algorithmic solutions. The rationales for these contexts are: (1) Creating story problems plays a pivotal role in establishing links between real-life situations and operations with fractions (Abu-Gyamfi et al., 2019). (2) providing real-world context when engaging in fraction division problems is critical because it helps not only to build a strong foundation for understanding fractions (Kent, Empson, Lynne, 2015) but also gives meaning to the division of fractions to students. (3) making connections among stories and diagrams in the problem with fractions are important because symbols help students make sense of fraction operations (Cengiz and Rathouz, 2011). Furthermore, this study examines solution strategies and the misconceptions of fraction operation tasks to better understand what it means to divide or multiply with fractional numbers (Newton, 2008). Taken together, the present study aims 1) to examine PSTs' conceptual understanding of fraction multiplication and division in three different situations, b) to explore PSTs' specific difficulties or misconceptions in engaging with multiplication and division.

Theoretical Framework

PST's Understanding of Fraction Multiplication and Division.

Research on teacher education continuously reports on the lack of conceptual understanding among preservice teachers on fraction multiplication and division. First area of struggles is the connection between the correct application of fraction operations and fraction word problems (Graeber & Tirosh, 1989; Ma, 1999; Seaman & Szydlik, 2007; Tirosh 2000). For instance, Graeber and Tirosh (1989) administered a written test to 129 preservice elementary teachers, and the test included 26 multiplication and division fraction word problems. The PSTs were asked to write an appropriate expression for the given word problems. The findings indicated that 25% of the respondents incorrectly wrote a division expression as an appropriate method to the solution for the problems involving fraction multiplication context. A parallel finding was documented in Tirosh's later study (2000) that PSTs provided multiplication expressions for fraction division problems. Tirosh explained that the participants' mistakes in finding the appropriate operation for the problems resulted from the misconception that multiplication makes always bigger, and division always makes smaller. Seaman and Szydlik (2007) revealed another example of PSTs' misuse of operational symbols in the word problem of fraction multiplication. For the problem "Brooke has a $\frac{3}{4}$ pound bag of M&Ms. If she gives $\frac{1}{3}$ of the bag to Taylor, what fraction of a pound does Taylor receive? (p.173)" all the participants were uncertain how to approach this story problem and most of them tried to apply fraction subtraction initially because of the word "give away". In the meantime, Ma (1999) focused on the conceptual analysis of the fraction division word problems written by Chinese and U.S. in-service teachers. Her research uncovered that many of US teachers were not able to come up with correct word problems that would match the given fraction equation, $1\frac{1}{2} \div \frac{1}{2}$. Among 23 U.S. teachers, six failed to create a story and 16 made up stories with misconception. Only one teacher was successful in creating a fraction division problem. These studies generally indicated that when asked to write an equation based on the word problems involving multiplication or division of fractions, PSTs tend to come up with incorrect operation in their equations and the connection between the two is a challenging task.

In a similar vein, other research group investigated PSTs' conceptual knowledge of fraction multiplication and division in terms of its multiple representations

(e.g., pictorial illustration, graphical representation using area model, linear models, part-whole model, etc.). (Adu-Gyamfi et al., (2019); Izsák, 2008; Lee & Lee, 2021; Lee et al., 2011; Luo et al., 2011; Son & Lee 2016;). One big idea shared in these studies was that many PSTs' struggle to visually represent the fractions when it comes with fraction multiplication or division. For instance, in the study of Lee & Lee (2021), PSTs were asked if a square-shaped cake on a geoboard was equally shared among 3 people and to justify if each part represented $\frac{1}{3}$ of the cake. They reported that majority of incorrect answers were associated with a misconception of area and a visual-dependent appraisal. In the study of Son and Lee (2016), 60 PSTs were asked to find $\frac{3}{4}$ of $\frac{3}{4}$ in the word problem context using graphical representations as if they were teaching to 5th graders. They found that 62 % of PSTs recognized the given word problem correctly as fraction multiplication but 11 % of PSTs failed to provide correct visual representations to explain the problem. The comparative study of Lou et al., (2011) reported also addressed that that many PSTs in both USA and Taiwan was not able to find the incorrect visual models for fraction multiplication equations such as $\frac{3}{4}$ of $\frac{4}{5}$.

Another main idea of the related research was about the pedagogical benefits of using visual representations in this operation. Son & Lee, 2016 underlined that various representations/models can be more helpful to make sense of an algorithm than representing fractions with a symbolic-only format, and it also can be used as a means of reasoning about fractional quantities (Izsák, 2008; Lee et al., 2011). More recently, Morano & Raccomini (2020) reported that PSTs strong conceptual knowledge of fraction operations were associated with the ability to accurately model fractions multiplication and division using visual representations and story problems. Their findings support the earlier findings of Adu-Gyamfi et al., (2019). Adu-Gyamfi and his colleague addressed that teachers' ability to draw visual representations is essential knowledge to teach fraction division conceptually because it allowed them to understand what kind of situations lead to fraction division and what kind of reasoning occurs in fraction division situations.

Mathematics Knowledge of Fraction Multiplication

The related research indicates that the important conceptual knowledge required in fraction multiplication is the concept of the whole (unit) (Lee et al, 2011; Mack 2001; Son & Lee, 2016). Son & Lee asserted that to fully understand fraction multiplication procedures understanding a fraction as part of a whole (two levels of unit, e.g., ¾ means "three of four parts") is not enough. These two levels of understanding should be expanded to three levels of unit understanding (e.g., ¾ means three-fourths of one whole). According to the study of Mack (2001), students were more successful with fraction multiplication problems when they demonstrated an understanding of the three levels of a unit such as various uses of portioning and units. In a similar vein, Lee at al., (2011) explained that to understand the meaning of fractions, multiplying fractions such as $\frac{2}{3}$ $\frac{2}{3}$x $\frac{2}{3}$, one should know the relationship between the fractional number and the referent unit. For instance, $\frac{1}{5}$ x $\frac{1}{5}$ can be interpreted as taking $\frac{1}{5}$ of a unit, and the referent unit is ⅔ of the whole and not $\frac{1}{5}$ of the one whole. Hence, the answer of $\frac{2}{15}$ should refer back to the same whole to which the $\frac{1}{5}$ referred to. The important role of the unit in the fraction is also emphasized in the study of Izsák (2008). He studied teachers' mathematical knowledge for teaching fraction multiplication, and this case surrounding teachers highlighted how important it is to have a full understanding of the three levels of units, not only to illustrate drawings correctly but respond to students' questions. In his study, the teacher explained that $\frac{2}{3}$ is bigger than $\frac{2}{3}$ by using the common denominator strategy (computation) but struggled to visually show why $\frac{3}{4}$ is bigger than $\frac{2}{3}$ using the area model of fractions. In addition, when representing $\frac{1}{5}$ of $\frac{1}{5}$ on the number line, the teacher had trouble responding to a student who was confused between one-fifth of a whole and one-fifth of a third. Through these findings, Izsák (2008) emphasized that teachers' understanding of the multi-level structure of the unit is necessary when using drawings to reason about fraction multiplication. These studies provide evidence that the knowledge of the unit is important to successfully perform fraction multiplication problems beyond its computational strategy.

Mathematics Knowledge of Fraction Division

In this study to explore PSTs' conceptual understanding of fraction division, the researcher applied the concept of whole number division because fraction division can be understood in connection with whole number division (Son & Crespo, 2009). The different conceptualizations of whole number division were addressed in many research studies (Ball 1990a; Ma 1999; Lo & Luo 2012; Van de Walle, 2010). Among them, division as a measurement and partitive concept was discussed before the data collection based on the course textbook (Van de Walle, 2010). The concept of whole number division, i.e., 10 (dividend) ÷ 2 (divisor) = quotient, can be interpreted in two ways. The first concept was finding the number of groups when the size of the group is known. For instance, if there are 10

cookies and each individual will have 2 cookies, how many people will have 2 cookies? This concept of division was described as measurement division (Ball, 1990) and the answer can be found by thinking of how many groups of 2 fit into 10 with the answer being 5.

The same equation (10 ÷ 2 = 5) can be interpreted differently such as in a sharing context when things are equally shared among the groups, i.e., 10 cookies are equally shared between 2 people. This type of division concept is known as partitive division. Prior research suggested that a sharing context (partitive division) would be a helpful approach to teaching fractions because of its intuitive nature (Van de Walle, 2010) but, at the same time, it limits the conceptual understanding when the divisor is a fractional number such as $\frac{2}{3}$ of a person (Lo & Luo, 2012).

As discussed within the section on fraction multiplication, understanding unit/unitizing is highlighted as an important piece of knowledge to build a conceptual understanding of fraction division (Lee, 2017; Lo & Luo, 2012). They explained, in measurement division, $2 \div \frac{2}{3}$ can be interpreted as "how many $\frac{2}{3}$ kg bags of rocks can you make from a total of 2 kg of rocks?" Students need to be able to conceptualize $\frac{2}{3}$ as a unit to measure 2 kg of rocks. However, this fraction equation is not easy to solve when considering partitive division problems because it is hard to imagine sharing 2 objects/things with $\frac{2}{3}$ people. It also requires students to think of division as the inverse of multiplication. In this scenario, the unit is not as clear as the measurement concept because the divisor is a fractional number. However, the situation would be different if a divisor is changed to a whole number such as $\frac{2}{3} \div 2$. This would be easier to solve with the partitive concept of division because students can think $\frac{2}{3}$ left of the cookie is shared by 2 friends solving for how much of the whole cookie each will have. As the author discussed the two meanings of whole number division with the participants, the author was interested in examining how their knowledge of whole number division would play out when they solve the fraction division problem.

In summary, this study had two major research questions. First, how preservice teachers would perform in solving fraction multiplication and division problems in three different contexts described above? Second, are there are any different patterns of difficulties (or misconceptions) in solving multiplication and division problems?

Methodology

Participants

The data for the present study came from 46 elementary preservice teachers (PSTs) who were enrolled in the elementary teacher preparation program at a mid-sized university in the western United States. The participants were in their senior year when they take their mathematics methods course. The researcher is a mathematics professor who teaches elementary mathematics methods courses at the university. The data were collected in the middle of the semester before the researcher covers fraction concepts to capture PST's prior knowledge regarding their conceptual understanding of fraction multiplication and division. Before fraction instruction, the instructor taught whole number multiplication and division, and two types of division concepts– partitive and measurement – were discussed and practiced. The concept of division was applied to the fraction division problems during the survey. The purpose of this was to explore if their drawings and posing word problems would differ by different concepts of division or the number relationship between the dividend or divisor. The researcher hypothesized that if the dividend is greater than the divisor, such as in the case of Q3 ($2 \div \frac{2}{3}$), it would be more appropriate to use a measurement approach to find out the solution because one can reach an answer by thinking how many groups of $\frac{2}{3}$ are contained in the dividend two. On the contrary, the partitive interpretation would be easier to solve the division task when the dividend is smaller than the divisor such as Q4 ($\frac{1}{3} \div 2$) by using a sharing context (e.g., $\frac{1}{3}$ pizza is shared by 2 friends).

The data collection method was a paper-and-pencil assessment with 10 problems that consisted of four fraction multiplication items and six fraction division items. To measure PSTs' conceptual understanding of fraction operations, the focus of tasks extended beyond a basic computational competency. The items were categorized into three parts: Part 1) four writing a story problem from a given fraction symbol, part 2) three solving fraction story problems, and part 3) three problems that require representing a visual diagram from fraction equations. The task items in part 1 were designed to measure PST's conceptual knowledge. These conceptual tasks required PSTs to make their own story problems to correspond with the multiplication and division of fraction equations. As Adu-Gyamfi (2019) argued, teachers need to be able to explain the meaning of fraction multiplication and division to their students since it is important to examine whether PSTs can identify when we use fraction operations in real-life situations

In part 2, PSTs' computational knowledge was a major focus. The items in this category asked the participants to solve the fraction word problems and show the process of how they solved the problems. Lastly, the items in part 3 asked PSTs to provide pictorial representations that would match the given fraction multiplication and division expressions. Drawing

a diagram was chosen because many teachers struggle with drawing diagrams to match algorithm solutions and such difficulties imply teachers' limited knowledge of fraction multiplication and division (Izsak, 2008, Lee, 2017). Part 3 was designed to measure PST's conceptual understanding of fraction operations along with their computational knowledge, especially to investigate if the participants were able to justify the algorithm procedures with appropriate visual representations. See below for the 10 task items.

The fractional numbers in this survey were selected based on 5th grade common core state standards because PSTs should know this concept first to be able to teach their students (Iskenderoglu, 2018). For instance, number and operation of fraction standards (5.NF.B.3) requires solving word problems involving division of whole numbers leading to answers in the form of fractions (Q5: 5 ÷ 2), or multiply a fraction x whole number (Q1: 3 x $\frac{1}{3}$) or fraction by a fraction (Q3: $\frac{1}{3}$ x $\frac{3}{4}$, Q8: $\frac{3}{4}$ x $\frac{1}{3}$). In terms of division standards (5.NF.B.7), students need to able to apply whole number division concept to divide unit fractions by whole numbers (Q4: $\frac{1}{4}$ ÷ 2) or whole numbers by unit fractions (Q9: 5÷ $\frac{1}{4}$). Common core state standards also ask students to use visual model to represent the fraction problems. (Q2: 2 ÷ $\frac{2}{3}$; Q10: $\frac{1}{4}$ ÷ 5). The 10 tasks are illustrated below.

The Task

Part I: From a symbol to a story

Using your own words, create word problems with the following fractional numbers:

Q1. 3 x $\frac{1}{2}$ Q2. $\frac{1}{3}$ x $\frac{2}{3}$

Q.2 ÷ $\frac{2}{3}$ Q4. $\frac{1}{3}$ ÷ 2

Part II: From a story to an answer

Solve the following problems and show your work.

Q5. March and Jada share 5 yards of ribbon equally. How much ribbon will each get?

Q6. It takes half a yard of ribbon to make a bow. How many bows can be made with 5 yards of ribbon?

Q7. Paula has 9 pounds of candy bags. If she uses ½ of what she has for Halloween, how many pounds will she have used?

Part III: From a symbol to a diagram

Multiply or divide the following fractions. Draw a model to explain your thinking.

Q8. $\frac{3}{4}$x $\frac{1}{4}$ Q9. 5 ÷ $\frac{1}{4}$ Q10. $\frac{1}{4}$ ÷ 5

Analysis

The 10 tasks are designed to assess multiple aspects of PSTs' understanding of fraction multiplication and division. To analyze the data, the researcher used both a scoring and coding system. The stories in part I and diagrams in part III were first scored as accurate or inaccurate. If a PST demonstrated a story problem and diagram that would result in the correct concept, it was scored as accurate. For diagram analysis, whether the participant provided the correct diagram or not was the most important criterion. If the participant provided an incorrect diagram but reached a correct answer with an algorithm, this work was coded as an incorrect diagram. After that, the stories and diagrams were analyzed using error codes. The error codes included new codes developed by the researcher and the codes aligned with common errors previously identified by Morano & Riccomini (2020). Some examples are missing or incomplete responses, modeling the equation, misrepresenting (multiple) wholes, and representing the answers, etc. For the items in part II, solutions to the story problems were scored as correct or incorrect and their strategies were also analyzed. First, the researcher categorized if the solution was correct or incorrect and then identified what strategies were used to solve the problems. Since multiple strategies were used and there were cases that one of the strategies was incorrect, the researcher coded each different case of the strategy used. At times, there were correct solutions with incorrect algorithms or diagrams, and the researcher counted them as correct with an incorrect algorithm because the correct solution was considered as a higher category. As part of the review process, the problems were analyzed by the author and one Ph.D. student. Initial analysis was performance individually between two of us. Later, it was discussed in depth multiple times in order to come up with the consensus. Table 1 summarizes how 10 tasks were coded with the coding rationale.

Results

Research Question One

The first research question of the study was to explore PSTs' general performances when engaging multiplication and division of fractions in various contexts. Figure 1 below shows the overall picture of PSTs' percent of accurate performance.

Among the 3 contexts of fraction problems (Part I, II & III) PSTs were most successful with Part II, solving a story problem, in both multiplication and division. In the meantime, we can observe the difficulties to create a story problem and represent visual models with fraction in both operations. The average of correct answers for making a multiplication story problem was slightly lower (31%) than division (35%) but the gap

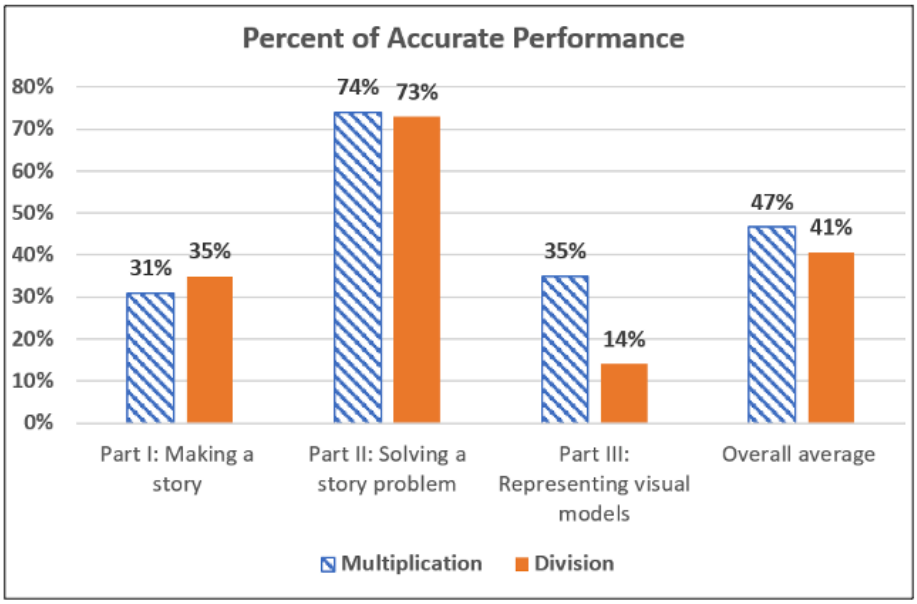
Table 1

Task Items and Analysis Chart

Task Items	Descriptions	Examples
Part I From a symbol to a story Q1: $3 \times \frac{1}{2}$	Accurate stories if the posed problems reflect: an understanding of multiplication concepts (e.g., repeated addition or part of the whole)	I have 3 friends. Each friend gets ½ a bag of candy. How many bags of candy did my friend get? (Part of the whole) I have 3 friends. Each friend gets ½ of a bag of candy. How many bags of candy did they have? (Repeated Addition)
Q2: $\frac{1}{3} \times \frac{3}{4}$	an understanding of redefining the whole (e.g., three levels of unit)	Sally has 1/3 of a yard of fabric and she uses ¾ of this fabric for a craft project. How much fabric does she use for her craft project? (Redefining of the whole)
Q3: $2 \div \frac{2}{3}$	an understanding of measurement division (equal grouping)	If you have 2 pies and each pie is cut into 3 pieces, and everyone ate 2 pieces How many people had pie?
Q4: $\frac{1}{3} \div 2$	an understanding of partitive division (equal sharing)	1/3 of a pizza was shared by 2 people. What fraction of the whole pizza was eaten by each person?
	In accurate stories, if there was a missing or incomplete problem	
	An inaccurate story if it models incorrect operations (e.g., used multiplication and subtraction concepts for division problem)	$2 \div \frac{2}{3}$: Jenny has 2 pounds of chocolate. If she uses 2/3 for the party tonight, how many pounds will she have left?
Part II From story to an answer Q5. March and Jada share ... Q6. It takes half a yard. Q7. Paula has 9 pounds...	Scored as correct if the solution was accurate The strategy was analyzed and recorded. Examples of Incorrect algorithms: $5 \div \frac{1}{2} = 2.5$, $2 \times \frac{1}{2} = 2.5$ $5 \times \frac{1}{2} = 10$	Correct answer with Correct Algorithm (CA) Correct Diagram (CD) Both CA & CD Incorrect Algorithm (IA) Incorrect Diagram (ID) CA with ID / IA with CD Incorrect answer Missing or Incomplete IA or ID
Part III From a symbol to a diagram Q8. $\frac{3}{4}$ of $\frac{1}{4}$ / Q9. $5 \div \frac{1}{4}$ / Q10. $\frac{1}{4} \div 5$	Accurate diagram if it visually shows the process of the problem with the correct answer. Inaccurate diagram if it lacks the process of the problem or the answer is missing	Accurate diagram (See Figures) Circle model or bar model Inaccurate diagram (See Figures) Missing or incomplete Modeling the equation Misrepresenting (multiple) wholes Representing the answers Unclear

Figure 1

Overall Percent of Accurate Performance



between the operations was much bigger in part III. Only 14 % of participants were able to solve fraction division problems by representing visual models.

Table 2 reports the frequency of correct answers by fraction problem types. Note that the correct answer total in Part II corresponds to the sum of 'correct answers with correct procedures total' and 'the correct answers with incorrect procedure total'. As stated previously, to deepen the study, PSTs' solution strategies were also analyzed and coded.

On the tasks in part I, PSTs' performance with $3 \times \frac{1}{2}$ (48%) was much better than the task of $\frac{1}{3} \times \frac{3}{4}$ (14%). It seems that $3 \times \frac{1}{2}$ was easier because PSTs applied the concept of whole number multiplication to create the problem, such as 3 groups of $\frac{1}{2}$ chocolate bar, and they used repeated addition to find out the solution. This strategy was not applicable anymore for the fraction x fraction problems. For division tasks, 23 PSTs (50%) were successfully created a story problem for $\frac{1}{3} \div 2$ using sharing context (e.g., $\frac{1}{3}$ bag of candy is shared by 2 people) but only 20 % of PSTs wrote the conceptually correct division problems for $2 \div \frac{2}{3}$

The problems in Part II, PSTs demonstrated comparable computational competency with fraction multiplication and division but, it is noteworthy that among the correct answers, the trend of solution strategies were different between the operations. For instance, in the problem of multiplication (9 x ½), there were 32 correct solution strategies and 75% (24 out of 32) presented correct algorithm and 22 % (7 out of 32) presented correct diagram and only one PST demonstrated both correct algorithm and the diagram. On contrast, for division solution strategies, 69 % (20 out of 29) and 70% (19 out of 27) of participants successfully demonstrated correct algorithm and the diagrams for the whole number and fraction division story problems. This result indicates that majority of participants were successfully solved both fraction multiplication and division story problems with correct algorithms, but they struggled much more with multiplication story problems when it comes to the connection with visual representation.

Furthermore, it was also noticed that some of the participants arrived at the correct answers with

Table 2

Participants' Overall Percentage of Correct Answers for Each Category.

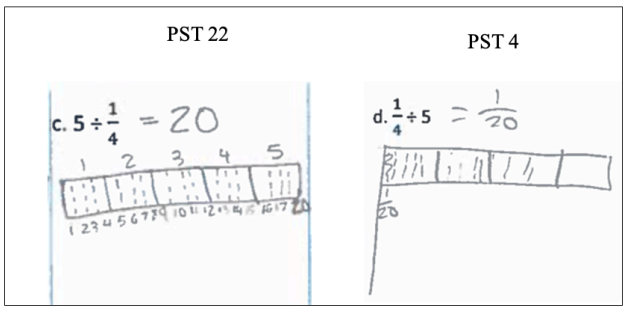
Task Category (*n* = 46)	Multiplication		Division	
Part I: Creating a story problem	$3 \times \frac{1}{2}$	$\frac{3}{4} \times \frac{3}{4}$	$2 \div \frac{2}{3}$	$\frac{1}{3} \div 2$
Conceptually Correct Story Total (Mul. 31% vs. Div. 35%)	22 (48%)	6 (14%)	9 (20%)	23 (50%)
Part of whole/Redefining whole	2	6	n/a	n/a
Repeated Addition	20	n/a	n/a	n/a
Measurement (equal grouping)	n/a	n/a	9	0
Partitive (equal sharing)	n/a	n/a	0	23
Part II: Solving story problems		$9 \times \frac{1}{2}$	$5 \div 2$	$5 \div \frac{1}{2}$
Correct Answer Total (Mul. 74 % vs. Div. 73%)		34 (74%)	36 (78%)	31 (67%)
Both Correct Answer and Procedure Total		32	29	27
Correct Algorithm Only		24	5	2
Correct Diagram Only		7	4	6
Both Correct Algorithm and Diagram		1	20	19
Correct Answer with Incorrect Procedure Total		2	7	4
Incorrect Algorithm		2	5	2
Incorrect Algorithm but Correct Diagram		0	2	1
Correct Algorithm but Incorrect Diagram		0	0	1
Part III: Representing Visual Models	$\frac{1}{3} \times \frac{1}{3}$		$5 \div \frac{1}{4}$	$\frac{1}{4} \div 5$
Correct Diagram Total (Mul. 35% vs. Div. 13%)	16 (35%)		8 (17%)	4 (9%)
Circle Model	0		1	0
Bar Model	16		7	4

incorrect solution strategies in part II. For instance, two participants reached to a correct answer for multiplication problem, but the algorithm was incorrect. Similarly, 11 participants who wrote down the correct answers for division problems did not demonstrate either correct algorithm or correct diagram for their correct answers. In case of these participants who reached to a correct answer with incorrect procedures we may assume that PSTs found the answers easily from reading the written problems and they did not need to do any calculation to solve the problems. However, when they were asked to show the process for the solutions either using algorithm or diagram, they made mistakes or did not know how to draw diagrams to solve the problem. The analysis for incorrect strategies will be further discussed in the next section of the results.

In part III, the analysis revealed an interesting result in terms of division diagrams. PSTs performed better with a fraction divided by a whole number (e.g., Q10: $\frac{1}{4} \div 5$) for creating a story problem, but in terms of drawing visual representations, the percentage of accurate answers for Q10 was lower (9%) than the equation with a whole number divided by a fraction (e.g., Q9: $5 \div \frac{1}{4}$, 17%). For Q10, only nine percent of participants were able to solve the division equations using visual model drawings. Figure 2 shows the successful examples of Q9 (5 ÷ ¼) and Q 10 (¼ ÷ 5). PST 22 demonstrated that she/he tried to find out how many groups of ¼ were in 5, and PST 4 demonstrated that $\frac{1}{4}$ was divided by 5 parts and the shaded part represented $\frac{1}{20}$. In case of PSTs who demonstrated correct visual representations, we can assume that they have a good conceptual understanding, according to Lee (2017) and Newton (2008).

Figure 2

Successful Diagram Examples in Part III (Q9 and Q10)



Research Question 2

After looking at the correct answers with solutions strategies, this section reports the error patterns observed from participants and describes how they were similar or different across three different contexts. Since the error patterns vary depending on conceptual understanding of multiplication and division, this section addresses the error patterns in multiplication first and that of division in the following section.

Error Patterns in multiplication problems

Table 3

Participants' Overall Percentage of Incorrect Answers for Multiplication Problems.

Task Category (n = 46)	Multiplication	
Part I: Creating a story problem	$3 \times \frac{1}{2}$	$\frac{1}{3} \times \frac{3}{4}$
Conceptually Inaccurate Story Problems Total	24 (52%)	40 (86%)
Missing or Incomplete	21	31
Modeling Inaccurate Operation	3	5
Misrepresenting the referent unit	0	4
Part II: Solving story problems	$9 \times \frac{1}{2}$	
Incorrect Answer Total	12 (26%)	
Missing or Incomplete	9	
Incorrect Algorithm	3	
Incorrect Diagram	0	
Part III: Representing Visual Models	$\frac{1}{3} \times \frac{1}{3}$	
Incorrect Diagram Total	30 (65%)	
Missing or Incomplete	23	
Misrepresenting the referent unit	4	
Unclear/other	3	

In terms of the error code of multiplication of fraction problems, 'missing or incomplete' was the biggest error type in all three contexts. Besides the missing or incomplete work, two error patterns were noticeable in Part I and the first one was modeling inaccurate operation. For instance, some of the participants wrote fraction division problems for the multiplication equations and the written work of PST 34 and PST 21 are the example of this error code. PST 34 wrote for $3 \times \frac{1}{2}$ as '$\frac{1}{3}$ of a cookie needs to be split with 3 friends' and PST 21 wrote for $\frac{1}{3} \times \frac{3}{4}$ as '$\frac{1}{3}$ of a pizza is shared with $\frac{3}{4}$. Both written problems required a division operation not a multiplication.

Another error pattern observed in Part I was not understanding the three levels of unit concept in the multiplication problems (Lee et al., 2011). See the examples below.

> *⅓ x ¾: The phone display is only showing 1/3 of the screen. If he only sees ¾ of the ads on his phone, how much of the 1/3 of this phone can actually be seen? (PST 37)*

> *⅓ x ¾: ⅓ of the boys in the class, and ¾ of the girls are wearing red shirts, what fraction of the class is wearing a red shirt (PST 39)*

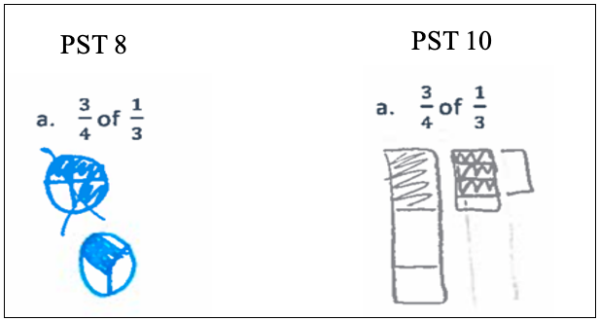
The response of PST 37 did not clearly refer to what 'his phone' means in the context (the whole screen or ⅓ of the screen), and PST 39 used two separate wholes (number of boys and number of girls). Both cases did not clearly represent the unit of each fractional

number and what each number referred to in terms of whole and the referent unit of the fraction.

Tasks in part II explored participants' computational knowledge through solving the real-life story problems and this was the most successful task for the participants. There were only three errors and it seemed that PSTs simply made arithmetic errors. The analysis of error patterns in part III revealed that PSTs demonstrated similar error patterns in part I and part III, which was misrepresenting the referent unit. See Figure 3 below as the example. When representing visually $\frac{1}{3} \times \frac{3}{4}$, PST 8 drew $\frac{1}{3}$ of one whole and $\frac{3}{4}$ of another one whole and did not show how $\frac{3}{4}$ is the referent unit of $\frac{3}{4}$. The work of PST 10 was little more advanced. This participant represented $\frac{1}{3}$ of one whole first and used the size of $\frac{3}{4}$ to represent $\frac{3}{4}$ of $\frac{1}{3}$. However, the visual model of PST 10 did not clearly demonstrate why the answer was $\frac{1}{4}$ or $\frac{1}{4}$ using $\frac{1}{3}$ as referent unit. Both cases indicated lack of conceptual understanding of referent unit in multiplication (Son and Lee, 2016).

Figure 3

Examples of the Error Coded as 'Misrepresenting the Referent Unit'



Error Patterns in Division Problems

Like multiplication problems, Table 4 shows that in the division problems, 'missing or incomplete' category is the biggest error pattern and 'the use of incorrect algorithm' is the next common error pattern in Part I. However, unlike the multiplication context, it is worth to note that PSTs' error pattern of 'modeling incorrect algorithm' varied by the division problem types (either partitive or measurement) or the number relationships between the dividend and the divisor. For instance, in part I, of the provided incorrect story problems for Q3 ($2 \div \frac{2}{3}$), the most common error was switching the dividend and the divisor, and it resulted in an incorrect algorithm. For Q3, most PSTs attempted to write problems using a sharing context, and it resulted in the mismatch between the story and the given equation of $2 \div \frac{2}{3}$. See the examples below:

> *2 ÷ ⅔: There was ⅔ left of a cake. Sam and John wanted to split what was left equally. How much of the cake will they get? (PST 24)*

> *2 ÷ ⅔: If I have two friends and ⅔ of a pie to share, how many pieces will each friend get? (PST 30)*

Table 4

Participants' Overall Percentage of Incorrect Answers for Division Problems.

Task Category (n = 46)	Division	
Part I: Creating a story problem	$2 \div \frac{2}{3}$	$\frac{1}{3} \div 2$
Conceptually Inaccurate Story Problems Total	37 (80%)	23 (50%)
Missing or Incomplete	18	16
Modeling Incorrect Algorithm	16	6
Misrepresenting the Whole	3	1
Part II: Solving story problems	$5 \div 2$	$5 \div \frac{1}{2}$
Incorrect Answer Total	10 (22%)	15 (33%)
Missing or Incomplete	5	4
Incorrect Algorithm	5	11
Incorrect Diagram	0	0
Part III: Representing Visual Models	$5 \div \frac{1}{4}$	$\frac{1}{4} \div 5$
Incorrect Diagram Total	38 (83%)	42 (91%)
Missing or Incomplete	34	32
Lack of conceptual understanding of division	1	5
Misrepresenting the whole	1	5
Unclear	2	0

For both examples, the written examples are represented as $\frac{2}{3} \div 2$, not as $2 \div \frac{2}{3}$.

Interestingly, the similar error pattern of switching the dividend and the divisor was rarely observed in Q4 ($\frac{2}{3} \div 2$). It seems that these errors are associated with the two different conceptualization of whole number division (Ball 1990a; Van de Walle, 2010).

In the meantime, for the tasks in part 2, the incorrect algorithm arose from the lack of distinction between dividing by 2 and dividing by one-half. Q6 (5 ÷ 2) asked how much ribbon each will get if 5 yards of ribbon are shared by 2 people. More than half of the participants who wrote down incorrect solutions demonstrated incorrect algorithm. Some of the examples are $5 \div \frac{1}{2} = 2\frac{1}{2}$, $5 \times \frac{1}{2} = 10$, and $5 \div \frac{1}{4} = 2.5$. It seemed that PSTs found the answers easily from the problem context but made mistakes when expressing the fraction division algorithm and did not recognize that their written equation did not produce the correct solution.

As already mentioned, division tasks in part III were identified as the most challenging tasks for PSTs and higher percentage of incorrect answers (83% & 91%) are the evidence of that difficulty. The common error types with division diagrams were 'lack of

conceptual understanding of division' and (Figure 4)' and 'misrepresenting the whole (Figure 5)'. It seems that these error patterns are associated with the relationship between dividend and divisor because it was identified only once for Q9 ($5 \div \frac{1}{4}$) but five times more for Q10 ($\frac{1}{4} \div 5$). For instance, the work of PST 27 in Figure 4 illustrated that there are five separate wholes, and each whole was divided into fourths. It seems that this participant represented the given equation with a drawing but was not sure how to represent the meaning of division (e.g., how many fourths are in five) visually. Similar errors were identified more frequently for Q11($\frac{1}{4} \div 5$). Looking at the examples of PST 19 and PST 28, they drew one rectangle to represent one whole and partitioned the whole into fourths. Next, she/he divided $\frac{1}{4}$ into 5 parts successfully. Yet, the diagrams did not clearly show how the correct solution was $\frac{1}{20}$. In particular, in the work of PST 28, she/he shaded $\frac{1}{5}$ of $\frac{1}{4}$ to represent $\frac{1}{20}$ of the whole but was not able to find out what the shaded piece represented in the context of division (e.g., sharing ¼ of brownie among 5 people and finding a portion for each).

Figure 4

Examples of the Error Coded as 'Lack of Conceptual Understanding of Division'

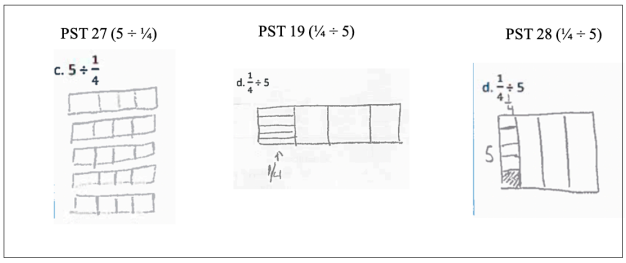
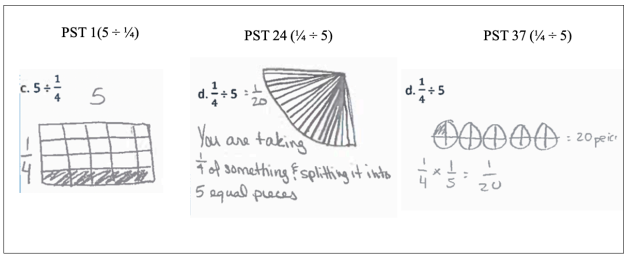


Figure 5

Examples of Error Type Coded as 'Misrepresenting Wholes'



The examples in Figure 5 reported the examples of misrepresenting the whole. In the first diagram of Figure 5 (PST 1: $5 \div \frac{1}{4}$), the one rectangle was represented as 5 wholes, and this whole was divided into four equal parts with $\frac{1}{4}$ represented by shading the part. The diagram was incorrect because the shaded part did not represent $\frac{1}{4}$ compared to the whole (1). Rather, it represented $\frac{1}{4}$ of five wholes. It seems that this participant misunderstood the five connected wholes as one whole by drawing one large rectangle instead of drawing five separate rectangles. When the fraction is defined based on the whole, what was shaded in this example was not $\frac{1}{4}$, but $1\frac{1}{4}$ (five groups of $\frac{1}{4}$ for each whole). When looking at the second picture (PST 24), the verbal explanation seems reasonable, but the pictorial illustration did not clearly represent what ¼ should look like in terms of one whole. It was not clear whether the presented circular sector represented the whole (1) or $\frac{1}{4}$. If PST 24 meant to represent the circular sector as one whole, the diagram could be right because it was divided into 20 equal parts despite the unclear representation of the dividend ($\frac{1}{4}$) in the picture. Yet, if one interprets the presented circular sector as $\frac{1}{4}$ (that shape typically is used to represent $\frac{1}{4}$ out of one whole circle), the diagram is inaccurate because $\frac{1}{4}$ should be divided by 5, not 20. Thus, this diagram was coded as incorrect due to its unclear representation of the whole (1) in the fraction.

Discussion and Implications

The purpose of this study was to provide a comprehensive description of elementary preservice teachers' conceptual understanding of fraction multiplication and division in three contexts and analyze the error patterns. Below the author summarizes the findings for each of the two research questions and suggests possible pedagogical implications for elementary mathematics teacher educators.

The first research question examined PSTs' overall performance on the fraction multiplication and division problems in three parts. Overall, the part II, solving word problems, was the most successful task in both multiplication and division of fractions with 73.5 % of correct answers. However, an in-depth analysis of solution strategies indicated that the majority of the PSTs applied algorithm to solve the problems and PSTs were more competent with fraction multiplication algorithm than the division algorithm. Of the correct solution multiplication strategies, 71% of PSTs solved the problem using algorithm only and two incorrect algorithmic mistakes were identified. On the contrary, with the fraction division word problems, just 10% of students solved the problems using algorithm only, and more frequent arithmetic errors were identified in division strategies. When comparing the use of diagram to solve the word problems, the percentage is much higher in division (more than 50%) than multiplication context (about 23%). One possible explanation is that an algorithm of fraction multiplication is simpler than fraction division because they just need to multiply numbers across fractions. Yet, this is not the case for division of fractions as the division algorithm requires the process called 'copy, dot, and flip'. Another possible explanation for the different use of strategies is that the context of the problems between multiplication and division. It seems that PSTs did not need to draw any pictures for the fraction multiplication problem

(Q7: $\frac{1}{2}$ of nine pounds of candy bags) because they could use mental math to find out the correct answer. However, for the division problems (sharing ribbons or measuring out the ribbon) they used drawings to represent the number or ribbons in the problems. The findings in part II are strong evidence that PSTs' fractional knowledge is procedure-based, and they are fragment (Ball 1990a; Park 2013). This finding emphasizes that teachers' knowledge needs to extend beyond computational competency to build deeper conceptual understanding of fraction concept (Adu-Gyamfi, 2019).

As past research has shown that division of fraction was most challenging especially with representing correct diagrams (e.g., Lee & Lee, 2019; Lee et al., 2011; Luo et al., 2011; Son & Lee 2016;), PST's lowest average rate of accurate diagrams in part III was not surprising. The PSTs' average rate of accurate answers of multiplication and division problems was the lowest with 20 % overall, but it was much lower with division problems. However, the findings from this study addresses one positive suggestion to support PSTs. It is true that PSTs were least successful with the drawings in part III, but as mentioned above, in part I, the average percent of accurate diagrams was much higher in the division problems than multiplication problems. The only difference was how the problem was provided. In part I, the fraction problem was provided using context and a story problem but in part III, only the equation was provided. The findings proved that providing context enabled PSTs to represent fractions with accurate diagrams in division problems. Thus, this study argues that providing context in division and multiplication problems is pivotal experience for PSTs to fully understand what situations lead to multiplication or division problems, and how to represent visual model correctly to teach fractions as sense making.

For the second research question, an in-depth analysis of data was conducted to identify the common errors observed across multiplication and division solution strategies.

According to the error analysis, the most common error of fraction multiplication and division was using incorrect application of fraction operations with word problems as described in the previous research (Ma, 1999; Tirosh, 2000). However, the findings of this study describe the difference of the errors between multiplication and division. The incorrect algorithm presented in multiplication problems were using different operation symbols (e.g., using division for multiplication problems). Yet, the error patterns in division problems were associated with the order of a dividend and a divisor (e.g., creating a story for either $2 \div \frac{2}{3}$ or $\frac{1}{5} \div 2$ or drawing a visual model for $\frac{1}{5} \div 4$ or $4 \div \frac{1}{3}$) because the different conceptualization of division may need to be applied (Adu-Gyamfi, 2019). PSTs' performance in this study was divergent depending on the division problem type. PSTs were more successful in creating story problems with the partitive division concept (e.g., $\frac{1}{3} \div 2$ or $\frac{1}{5} \div 4$) but when generating visual representation, their performance was much better with the measurement division concept (e.g., $2 \div \frac{1}{5}$ or $4 \div \frac{1}{5}$). PSTs are prone to develop the division problem by sharing context, but they have difficulties solving the problem conceptually using visual models. A discrepancy existed between creating the problem and meaningfully solving the problem. This finding suggests teacher education courses need to encourage PSTs to discuss the meanings of two different concepts of division in whole numbers, how this approach could be used in fraction divisions, and how this approach would differ depending on the relationships between the dividend and divisor in fraction problems. Further, this study recommends providing an opportunity to think about the pros and cons of applying the different concepts of whole number division into division with fractions. This conceptual challenge in learning division should be fully discussed prior to learning and teaching fractions. These in-depth discussions could support PSTs to understand what it means to divide and multiply fractions in our daily lives.

The finding of this study brings an attention to the PSTs' lack of fractional number sense. If PSTs understand the relationship between the dividend and divisor of the whole number, they should be able to identify Q10 ($4 \div \frac{1}{5}$) cannot have the same answer as Q9 ($\frac{1}{5} \div 4$) and to determine which answer should be bigger than 1 or smaller than 1. For instance, if one understands multiple conceptualizations of division concepts (e.g., finding a quotient, ratio, and measurement, etc.) she/he needs to be able to tell $\frac{1}{5} \div 4$ means either how many groups of 4 fit into $\frac{1}{5}$ or $\frac{1}{5}$ of pizza is shared by 4 children. In both cases, the answer should not be bigger than 1. The same logic can be applied to Q10 ($4 \div ⅕$). As ⅕ goes into 4 more than 1 time, the answer should be a lot bigger than 1. This type of practice could be helpful for students to connect a student's prior knowledge of whole number division with an earlier understanding of fraction division building fractional number sense at the same time. Fractional number sense can help PSTs and their future students to reduce misconceptions

Another common error identified in this study was the misrepresenting the whole in division and not understanding the referent unit in multiplication problems. Both are critical elements to conceptually understand fraction multiplication and division, thus, it is critical to practice identifying the whole(s) and the referent unit with carefully designed fraction problems. Concerning this, Mack (2001) posed a couple of suggestions. For instance, the problems start from an equal-sharing context, and move to finding a

fraction of a whole number, taking a part of a part of a whole (e.g., ¼ of ⅘), and choosing fractional numbers carefully where the relationships between numerators and denominators are easily represented visually, etc. (e.g., ¾ of ⅔). These carefully chosen problems would be a great opportunity for students to practice partitioning units in various ways and conceptualizing the critical concept of fraction multiplication and division.

To this end, the results of this study summarizes some potential implications to support PST to be able to teach fraction multiplication and division meaningfully and conceptually. It includes:

- Helping PSTs to connect to context when solving and representing problems visually.
- Helping PSTs to explicitly connect the various meanings of fraction division and real-life examples.
- Providing ample discussion time about the conceptual meaning of division with whole numbers prior to multiplication and division of fractions with the emphasis of the relationships between a dividend and a divisor.
- Providing carefully selected fractional numbers considering the level of difficulties
- Helping PST to build fractional number sense to justify their answers.

There are still some questions that remain unanswered. Future studies will include interviews to explore PSTs' mathematical thinking in detail and will focus on pre- and post-test to find out which instructional strategies are helpful to enhance conceptual understanding. Further, a bigger sample size will make the study more robust. Also, it will be beneficial to broaden the scope and sequence of the task levels for each category such as including a conceptual understanding of whole number division. We hope future research will shed some light on promoting PSTs' conceptual understanding of the most challenging topic in elementary school mathematics.

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Handwriting Speeds of 4th–8th Grade Students*

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Abstract

For the effective expression of feelings and thoughts, handwriting should be produced fluently at a certain speed. The aim of this study was to examine the development of handwriting speeds in 4th–8th grade primary and secondary school students in terms of somevariables. In line with this aim, answers were sought to the question, "Do 4th–8th grade primary and secondary school students' handwriting speeds differ significantly depending on their grade, gender, hand preference, and handwriting style?" The study was designed inthe survey method, and the study group consisted of 322 students attending the 4th, 5th, 6th, 7th, and 8th grades of primary and secondary school. A form developed by the researchers for all grade levels was usedas the data collection tool in the study. In the data collection process, the students were required to copy a given text within one minute. The research results revealed that while the primary and secondary school students' handwriting speeds differed significantly according to their grade level, gender, and handwriting style, they did not differ significantly according to their hand preferences. As the grade level increased, mean handwriting speeds also increased. Female students wrote faster than male students. Students using the manuscript handwriting style wrote faster than students who used the cursive handwriting style.

Keywords:

Handwriting Speed, Primary and Secondary School Students, Handwriting Style, Hand Preference

Introduction

Handwriting is a language skill that begins with the ability to produce letters, and it is necessary for students to be able to express themselves, their feelings, and their thoughts. As Temur, Aksoy, and Tabak maintains, "Writing begins with various scribbling and drawing activities and requires coordinated movements of the elbow, shoulder, and trunk muscles with the hand and wrist muscles" (2012, p.311). Güneş (2016) defines handwriting as a skill that requires various processes such as "holding a pencil, writing the letters, activating prior knowledge, organising, reviewing, and textualizing" (p.20). As the definitions suggest, handwriting skills entailspecific skills and stages. Tompkins et al. (2014) discuss this process in three stages: preparation for writing, starting writing, and gaining fluency. At the preparation for writing stage, children need to recognise the

units (letters, words, sentences, and texts) that make up writing (Güneş, 2007). Subsequently, an attempt is made to foster handwriting skills in students from the 1stgrade of the primary school and onwards (Ziviani & Watson-Will, 1998). According to Bara and Morin (2013), in the early stages, students must learn the shape, connections, and the direction of movement of letters. Therefore, handwriting performance requires the careful and simultaneous use of a number of cognitive (e.g., intellect, attention), sensory, and psychomotor (e.g., motor development, muscle development) behaviours (Dodd & Carr, 2003, p.128). Alongwith these behaviours, handwriting is affected by social factors such as constraints to use the right hand and environmental factors such as the literacy curriculum (Ziviani & Wallen, 2006). Handwriting quality increases more rapidly during the first years of learning and develops more slowly at later ages (Karsldottir & Stefansson, 2003). Handwriting requires cognitive effort not only for children at the beginning of the literacy process, but also for students at all grade levels (Morin, Morin, Lavoie, & Montésinos-Gelet, 2012) since writing needs to be produced fluently at a certain speed so that feelings and thoughts can be expressed effectively at all stages of learning.

A high handwriting speed is essential in terms of written communication as well as academic success (Phelps, Stembel, & Speck, 1985; Tseng & Hsueh, 1997). Young children reserve most of their cognitive energies for the motor aspect of writing (Morin, Lavoie, & Montésinos-Gelet, 2012). Therefore, in this process, for students to write accurately and fluently, teachers should pay attention not only to what students write, but also to how they write (Taylor, 2010, as cited in Başaran, 2020). When handwriting skills become more automatic, the attention and cognitive resources that are used to carry out other learning processes will mostly be used to develop the content of writing (McCutchen, 2011). Graham and Weintraub (1996) expressed this situation as children'sforgetting andnot recalling all their ideas while putting them on paperif they write slowly. In a study by Medwell, Strand, and Wray (2009) in Britain with children who finished primary school, it was revealed that handwriting, especially the ability to produce letters automatically, has an important role in text quality. If children do not produce letters at a certain speed and with a certain legibility, they cannot convert their ideas into written texts.

The aim of teaching handwriting is to enable children to produce rapid and legible handwriting (Galanis, 2008). Failure in this learning process may affect school success (Vinter & Chartrel, 2010) and may cause writing problems such as inconsistency and slowness in writing speed (Akyol, 2014).Since copying, note-taking, composition writing, and written exams are based on their handwriting ability (Bara & Morin, 2013),students with high handwriting speeds are at an advantage compared to other students when putting their ideas in writing.

Particularly in the 1st grades, children's acquisition of the skill of orderly and legible handwriting at a suitable speed is important in both educational and social sense (Yıldız & Ateş, 2010; Ziviani & Watson-Will, 1998). Therefore, legibility and writing speed are the two most important criteria in the development of handwriting (Akyol, 2008; Galanis, 2008; Graham et al.,1998). Sincethe handwriting speed is known to be directly related to students' ability to express their feelings and thoughts, it has been the subject of scientific research studies for many years. It is generally understood that letters written within a certain time period are taken into consideration for determining handwriting speed (Akyol, 2008). Freeman (1954) was the first researcher to suggest the number of letters written per minute to measure handwriting speed and create a norm (as cited in Tseng & Hsueh, 1997).

Various studies were conducted with different grade levels to assess the handwriting speeds of students. Basic findings regarding mean handwriting speeds determined in some studies withdifferent grade levels are presentedin Table 1.

In the table, the fact that the research findings show differences in mean handwriting speeds may be due

Table 1

Mean Handwriting Speeds by Copying According to Different Grade Levels

Researcher(s)	Country	Number of students	Duration (minutes)	Grade level and words per minute								
				1	2	3	4	5	6	7	8	9
Ziviani& Elkins (1984)	Australia	575	2	-	-	32.6	34.2	38.4	46.1	52.1	-	-
Ziviani (1984)	Australia	575	2	-	-	33	34	38	46	52	-	-
Phelps, Stempel, & Speck (1985)	USA	1365	2	-	-	35	46	54	66	-	-	-
Hamstra-Beltz & Blote (1990)	Germany	127	5	-	24	35	46	54	66	66	-	-
Graham et al. (1998)	USA	900	1.5	19	34	47	63	73	85	100	115	118
Temur (2012)	Turkey	75	2.5	-	-	115	-	-	-	-	-	-
Jimenez & Hernandez-Cabrera (2019)	Spain	1124	1	5	6	-	-	-	-	-	-	-
Türker & Tunç (2020)	Turkey	95	1	-	-	51	55	-	-	-	-	-
Skar et al. (2021)	Norway	4950	1.5	16	29	39	-	-	-	-	-	-

to the effect of variables such as students' individual differences, the number of students included in the sample, the country's language characteristics, and the use of different words or texts (Temur, 2012). Regarding language features, Turkish is a transparent language. Since the letter-sound relationship in transparent languages is almost standard (one sound corresponds to one letter), it facilitates the learner's acquisition and development of literacy skills. For this reason, Turkish literacy is taught and learned in a relatively short time. Moreover, it is stated that the time required to write a letter varies according to itsshape and size, and since the shapes of some letters are simple, they are easily produced,and thus, the time taken to write each letter is not equal (Güneş, 2016). Besides these, it can be said that the method used to measure handwriting speed (dictation or copying) is one of the factors causing differences in handwriting speed.

In addition to the studies above, there are also studies in which the effect of handwriting style on handwriting speed is examined. Some of these state that cursive handwriting is written faster than manuscript handwriting (Foster, 1957; Graham & Miller, 1980; Kazu & Ersözlü, 2006). In manuscript handwriting, since there is a pause after each letter, the handwriting process is interrupted and slowed. On the other hand, in cursive handwriting, since the student does not have to continue writing by frequently lifting his/her hand and finding the writing point again, his/her handwriting speed increases (Akyol, 2008; Güneş, 2006; Güneş, 2007; MEB, 2009). However, in some studies, it is revealed that while writing cursive letters, the student has to change the movement of his/her hand more (Graham,1992), and it is stated that manuscript letters are learnt more easily and written more rapidly than cursive handwriting (Bara & Morin, 2013; Berninger et al., 2006; Gates & Brown, 1929; Houston, 1938; Turan, 2010; Yıldız et al., 2016; Yıldız, 2019). Arslan and Ilgın (2010) maintained that teaching different handwriting styles could create problems for students and lead to students writing with a mixed style, which could have a negative effect on the legibility and the speed of handwriting in later grades.

In the study that they conducted with 600 students in 4th–9th grades, Graham, Berninger and Weintraub (1998) determined that there was no significant difference between beginning literacy with manuscript or cursive letters in terms of speed and legibility. Morin, Lavoie, and Montésinos-Gelet (2012) examined letter writing, word copying, and text creation skills over a 45-minute period in 715 Canadian 2nd grade students who learned literacy with different handwriting styles. It was concluded that students who learned literacy with cursive handwriting made more progress in the areas of word production and syntax than students who learned the other handwriting styles. They explained this situation by stating that in cursive writing, in contrast tomanuscript letters, all the letters of the word are interconnected, which enables students to memorise word units more easily and facilitates their recall. In a study by Bara and Morin (2013), in which they examined the handwriting speed, legibility of written texts, and handwriting styles in 4th and 5th grade students according to the handwriting style they had learnt in the 1stgrade, significant differences were found between grade level, handwriting style, handwriting teaching method, and countries. It was concluded that Canadian students wrote faster than French students, but their handwriting was less legible, the cursive handwriting speed was slower than a mixed handwriting style, and the handwriting speed and legibility improved as the grade level increased. In a study conducted with 9th grade students who had begun their first literacy education with cursive writing, Aydın (2016) determined that seeing two different handwriting styles used in class created problems for students, and this situation had a negative effect on the handwriting speed and legibility in later grades.

When other studies related to handwriting speed are examined, it is seen that variables such as gender, grade level, and hand preference are generally taken as the basis for comparisons. In their study, Graham and Weintraub (1996) reported that the relationship between handwriting speed and grade level might not always be linear. As a result of the study by Tseng and Hsueh (1997), which aimed to examine the handwriting speeds of 1525 Chinese children in 2nd–6th grades, it was reported that the handwriting speed increased with age, the rate of increase was greater among the 2nd, 3rd, and 4th grades, and girls wrote faster than boys in the 3rd, 4th, and 5th grades. In the study carried out with a total of 900 students between the 1st and 9th grades by Graham et al. (1998), it was revealed that female students wrote faster than males at the beginning and end of primary school and at the beginning of secondary school, that right-handed students wrote faster than left-handed students, and that the handwriting speed showed a tendency to increase from one grade level to another. As a result of the study conducted by Ziviani and Watson & Will (1998), in which they examined the handwriting speeds and text legibility of 372 students aged between 7–14, it was stated that there was no significant difference between the mean scores for handwriting speed in male and female students, but girls were better than boys in terms of legibility, and there was a significant difference in text legibility according to gender, while a weak correlation between speed and legibility was found. O'Mahony, Dempsey, and Killeen (2008) concluded that hand preferences of students aged 8–18 had no effect on their handwriting speed, but the handwriting speeds of students attending schools that were named as disadvantaged were below average. As a result of his study, Bay (2010) determined

that there was no significant difference between female and male students attending the 1stgrade in terms of handwriting speed. In their study examining the effect of 1st grade students' pencil holding styles, pencil gripping, and compressive strengths on their handwriting speeds and errors,Temur, Aksoy, and Tabak (2012) reported that students' pencil gripping points affected their handwriting speeds, and girls' handwriting speeds were faster than those of boys. Temur (2012) aimed to evaluate Turkish and American 3rd grade students' handwriting speeds in terms of the variables of degree of flexion of the index finger and the position of the thumb and the forearm. As a result of the study, it was reported that the degree of flexion of the index finger did not lead to a significant change in students' mean handwriting speeds, whereas the forearm and thumb position had an effect on mean handwriting speeds. Moreover, it was determined that Turkish students' handwriting speeds were higher than those of American students, and in students of both countries, girls were more successful than boys in writing skills. Aydın (2016) determined that 9th grade female students who had learnt literacy first with cursive handwriting had higher mean handwriting speeds than male students in both cursive and manuscript types of handwriting. In anotherstudy conducted with 95 students attending 3rdand 4thgrades of primary school, Türker and Tunç (2020) examined students' manuscript handwriting speeds with regard to the variables of gender, age, grade level, hand preference, statusof receiving preschool education, class type (independent or combined class), and class size. The results of the research revealed that students attending independent classes wrote faster than students attending combined classes, but no significant differenceswere foundin terms of the other variables.

The studies conducted offer different perspectives related to primary and secondary school students' handwriting speeds. O'Mahony, Dempsey, and Killeen (2008) state that handwriting speed is clearly an important factor worthy of examination on its ownbecause copying a text, taking notes, and free-writing tasks are among the most common writing tasks in school (Fogel, Rosenblum, & Barnett, 2022). Moreover, writing as a skill takes time for students. Spending too much or little time on typing tasks depends on writing speed.Hammerschmidt and Sudsawad (2004) indicated that while evaluating students' handwriting, teachers judge whether the writing is quick by comparing students with their peers. This situation makes it important to carry out this study and supports the idea that writing speed should be examined according to grade levels or age because there is no standard or norm for writing speed in terms of class levels. The statement that writing speed increases as grade level increases remainsvalidonly in theory or expectation.

When studies conducted on this subject in Turkey are examined, it is seen that they have generally been made with a single class level, e.g., with 1st grades (Bay, 2010; Duran & Akyol, 2010; Erdoğan, 2012; Kadıoğlu, 2012; Temur, Aksoy, & Tabak, 2012) and 3rd grades (Temur, 2012; Türker & Tunç, 2020). Therefore, there is a need for further research aimed at determining students' handwriting speeds comparatively. Some of the main writing tasks of students at school is answering questions in examsand classwork, such as copying from the board to notebooks or doing homework (Barnett, Prunty, & Rosenblum, 2018). Studies have stated that the inability to produce legible letters automatically and effortlessly at an appropriate speed may be an indicator that a child is at risk for developing inadequate composition skills (Berninger & Amtmann, 2003), low achievement, and low self-perception (Feder & Majnemer, 2007). Research about writing speed can inform countries about determining and controlling the variables that may affect the speed of writing (e.g., letters are produced more effortlessly in cursive handwriting, right-handed people write faster) whiledesigning curricula about language and writing skills.This study has been designed with the aim of filling the gap that exists due to this deficiency by examining the development of students' handwriting speeds with regard to severalvariables. Within the scope of the research, answers were sought to the question, "Do 4th–8th grade primary and secondary school students' handwriting speeds differ significantly depending on their grade, gender, hand preference, and handwriting style?"

Method

This study was designed as a survey method toexamine whether primary and secondary school students' writing speed is affected by variables such as grade level, gender, hand preference, and writing style. "Survey research enables to reveal what is experienced or what already exists. The researcher does not intervene in these phenomena or situations, he takes the phenomenon as it is, how it works, and examines it" (Sönmez & Alacapınar, 2017, pp.47-48).The study intended to describe the writing skills of a large sample of participants.

Study Group

Table 2
Distribution of Participating Students According to Their Gender and Grade Level

Gender	Grade Level					Total
	4	5	6	7	8	
Female	41	30	44	29	26	170
Male	33	35	27	30	27	152
Total	74	65	71	59	53	322

The study group of the research consisted of 322 students attending 4th, 5th, 6th, 7th, and 8th grades of primary and secondary schools in three state schools located in the city centres of Ankara, Trabzon, and Giresun provinces (Table 2). In order to determine the study group, the convenience sampling method was used since voluntary participants were selected in schools that could be easily and quickly accessed in the provinces where the researchers were employed. The aim of this sampling technique is to select cases where participants who are willing to take part can be included in the research according to the principle of convenience (Patton, 2014). For this reason, an effort was made to reach a certain number of students (at least 30) from each class in each grade. The reason for starting the assessment of primary school students'handwriting speeds from the 4thgrade of primary school was that the handwriting skills of students in the 1st, 2nd, and 3rd grades are still in the process of motor development. Moreover, they do not usually gain the fluencyneeded in handwriting skillsto express themselves in these grade levels yet. Students begin to organise their ideas and put them in writing more efficientlyonce they have learnt to write letters, syllables, and words legibly and correctly (Tompkins et al., 2014). They generate a writing character specific to themselves by beginning written homework, tests, and longer written exercises from the 4thgrade and onwards, whereas especially in the first three years of primary school, they are expected to acquire an adequate level of handwriting skill as a means by which they can conduct their schoolwork (Yıldız &Ateş, 2010, p.13).

Data Collection Tool

In order to determine the handwriting speeds of the students in the study, a form that was developed by the researchers was used. The form consisted of a single text for all grade levels (a paragraph taken from an informative textfor determining students' handwriting speeds), and questions related to students' grade levels, gender, and hand preferences. Tocreate the form, first,the literature was reviewed, and the criteria based on the assessment of handwriting speed were examined. Drawing upon these criteria, an informative text which was included in the primary school Turkish textbook andwhich was considered suitable to be read in schools by the Board of Instruction and Discipline of the Ministry ofNational Education was selected. While choosing the text, care was taken to ensure that the text contained a topic on which all students could meet on common ground by obtaining the views of three fieldexperts. The informative text consisted of 49 words and 314 letters which included all the lowercase letters of the alphabet at least once, with the exception of j, p, and u.

Students come across informative texts more frequently in textbooks and in their daily lives. The selected text from the Turkish textbook contains a suitable topic for all grade levels.The students were asked to copy and write the following text in the data collection form in one minute using the handwriting style they wished (SeeAppendix for its translation):

"Türkiye iki kıta üzerinde yer alan, dört mevsimin doyasıya yaşandığı cennet gibi bir ülkedir. Ülkemiz üç tarafı denizlerle çevrili, bol güneşli, birbirinden güzel sahillerini size cömertçe sunar. Bitki örtüsü ve hayvan türleri bakımından son derece zengindir. Bu topraklar camileri, kiliseleri, heykelleri, sarayları, medreseleri ile geçmişi her an yaşar gibidir."

Data Collection Process

After obtaining the necessary permission from the schools to collect the data forthe study,students in the classrooms of teachers who were able to voluntarily spare time for the research were requested to copy and write the text on the form within one minuteto determine their handwriting speeds. Before the text was written down by the students, information was given about the activity they would perform as follows:"The purpose of this study is to determine your writing speed in one minute. You can use any handwritingstyle (cursive or manuscript) you want." Students were given some time to prepare for writing, such as taking appropriate sitting positions for writing and preparing theirwriting tools.Next, with the instruction "you can start writing," the one-minute period began. At the end of one minute, with the instruction "you can stop writing," the students were asked to circle the last letter they had written and put down their pencils. In granting a period of one minute, the study by Graham et al. (1998) was taken as reference.

Data Analysis

For the analysis of the research data, descriptive statistics (percentage, frequency, arithmetic mean, standard deviation, and kurtosis and skewness values) were used to evaluate the writing speed of the students by analysingthe number of letters written per minute according to the grade levels, and two-way analysis of variance was used to determine whether there was a difference between the groups. While investigating the effect of more than one independent variable on the dependent variable, the examination of two different effects at the same time by taking into account of the interrelated interaction of independent variables and the case of interaction between variables is known as "interactive analysis of variance" (Karagöz, 2019, p.445). Accordingly, the handwriting speed of primary and secondary school students (4th–8th grades) wasthe dependent variable, and with grade levels as covariate, students' gender, hand preferences, and handwriting styles were dealt with as independent variables.

Firstly, among the total 341 student forms that were collected, 19 illegible oneswere removed from the data set. Therefore,the analyses were carried out with 322 students. The SPSS software was used in the data analysis. In the analyses made, the Cronbach alpha values of .05 and .01 were taken as the levels of significance. The suitability of the data forparametric testswas examined in terms of normal distribution (skewness and kurtosis values should be between -1 and +1). Skewness and kurtosis values between -1 and +1 are the most important indicators of mutually overlapping (equal or nearly equal) normal distribution of the arithmetic mean, mode, and the median (Can, 2013, pp.82-89). Accordingly, the arithmetic mean and the standard deviation values for the data were examined, and the skewness and kurtosis coefficients were taken into account. The measures of central tendency and normality values related to the data are presented in Table 3.

Table 3

Measures of Central Tendency and Normality Values oftheData

Grade	*n*	Lowest	Highest	*M*	*SD*	Skewness	Kurtosis
4	84	33	99	59.50	14.81	.389	-.279
5	65	25	132	76.08	25.5	.352	-.458
6	71	28	144	94.46	23.30	-.162	.121
7	59	41	159	104.63	26.78	-.007	-.479
8	53	49	161	116.79	30.11	.541	.567

Asdemonstrated in Table 3, the skewness and kurtosis values for the handwriting speeds according to grade level are between -1 and +1, and thus, thescores in the data set for the students show normal distribution (Tabacnick & Fidel, 2015). Further, the test results for the homogeneity of variance are presented in Table 4.

Table 4

Results of Levene's Test for Homogeneity of Variance

Dependent Variable	SD1/SD2	F	p
Handwriting Speed	33/288	1.22	.20

Table 4 reveals that according to the results of Levene's test for determining homogeneity of error variances, there is no significant difference between the groups in the distribution of error variances of the dependent variables (F = 1.22, p >.05), and the variances are homogeneous. In this case, to ascertain whether there is a significant difference between the mean values of handwriting speed (the dependent variable) according to the factors of the independent variables, two-way ANOVA can be performed.

Findings

In this section, the descriptive findings related to the independent variables of grade level, gender, hand preference, and handwriting style, and the two-way ANOVAfindings for mean handwriting speeds are presented by taking the research question as the basis. Before the text was copied, it was stated that students could use any writing style (cursive or manuscript) they wanted and that they had one minute to write. In Table 5, the arithmetic mean and standard deviation values for the grade level, gender, hand preference, and handwriting style variables for handwriting speed are presented.

As Table 5 shows, the general findings for handwriting speed reveals thatthe mean values related to handwriting speed increase as the grade level increases, mean values related to handwriting speed also increase. Moreover, although the speedvaries according to grade level, it can be said that girls write faster than boys, and right-handed students write faster than left-handed students. It is also striking that apart from 4thgrades, students who write with manuscript handwriting have higher mean handwriting speeds than those who write with cursive handwriting.

Following the descriptive findings, the results of the two-way ANOVA, which was performed to holistically evaluate the significance and size of the effects of the independent variables on the dependent variable, are given in Table 6.

An examination of Table 6 shows that the effect of the grade level variable on handwriting speed is significant ($F(4, 314) = 35.38$, $p < .01$) and that the effect on handwriting speed is η^2=.31. It can be said that grade level is the most effective variable, explaining 31% of the variance in handwriting speed. According to the results of Tukey's multiple comparison test, which was performed to determine in which grades this effect achieved was significant, it was determined that the difference in students' handwriting speed in the 4th grade (M = 59.50) and 5th grade (M = 76.07) was significant both between themselves and amongthe other grades. However, it was revealed that the difference between the 6th grade (M = 94.46) and7th grade (M = 104.62) and the difference between the 7th grade (M = 104.62) and 8th grade (M = 116.79) was not significant. This situation shows that handwriting speed increases from the 4th grade onwards, but the difference between some grades is not statistically significant. Furthermore, it can be seen in Table 6 that the effect of gender on handwriting speed is significant ($F_{(1, 314)}$=39.29, $p < .01$), and the effect on handwriting speed is η^2=.11. When the mean values included in Table 5 are examined, it is seen that female students' mean handwriting speeds are higher than male students' at all grade levels. This situation shows that gender is an effective variable that explains 11% of the variance in handwriting speed. It can be understood from Table 6 that another variable having an effect on handwriting speed is the handwriting

Table 5

Students' Mean Handwriting Speeds According to Grade Level, Gender, Hand Preference, and Handwriting Style

Grade		Gender		Hand Preference		Handwriting Style		Total
		Female	Male	Right	Left	Cursive	Manuscript	
4	*n*	41	33	64	10	61	13	74
	M	61.41	57.12	59.51	59.40	59.50	59.46	59.50
	SD	13.87	15.78	15.23	12.40	14.66	16.09	14.80
5	*n*	30	35	52	13	33	32	65
	M	81.50	71.42	76.69	73.61	65.42	87.06	76.07
	SD	22.97	27.05	26.06	24.18	21.84	24.72	25.56
6	*n*	44	27	62	9	13	58	71
	M	102.40	81.51	95.98	84.00	81.15	97.44	94.46
	SD	19.85	22.98	23.16	22.71	28.13	21.22	23.29
7	*n*	29	30	53	6	13	46	59
	M	120.06	89.70	106.41	88.83	91.76	108.26	104.62
	SD	19.89	24.15	26.16	29.47	24.67	26.47	26.78
8	*n*	26	27	50	3	6	47	53
	M	128.23	105.77	118.50	88.33	95.16	119.55	116.79
	SD	29.95	26.33	29.88	19.85	15.01	30.51	30.10
Total	*n*	170	152	281	41	126	196	322
	M	95.79	79.82	90.08	75.73	68.32	101.07	88.25
	SD	32.13	28.45	32.03	23.72	22.76	29.54	31.43

Table 6

Two-way ANOVA Related to the Effects of Grade Level, Gender, Hand Preference, and Handwriting Style on Handwriting Speed

Variable	Sum of Squares	*df*	Mean Square	*F*	*p*	η^2
Grade Level	68235.16	4	17058.79	35.38	.00	.31
Gender	1822.54	1	18944.61	39.29	.00	.11
Hand Preference	1822.54	1	1822.54	3.78	.06	.05
Handwriting Style	7835.69	1	7835.69	16.25	.00	.05
Grade Level x Gender	7008.92	4	1752.23	3.53	.01	.04
Grade Level x Hand Preference	2780.22	4	695.05	1.21	.31	.02
Grade Level x Handwriting Style	3639.05	4	909.76	1.68	.15	.02
Error	151370.80	314	482.07			
Total	2825142.00	322				

*p>.05

style, with an effect of $F_{(1, 314)} = 16.25$, $p < .01$. It is seen that handwriting style explains 5% (η^2=.05) of the variance in handwriting speed. When the mean values included in Table 5 are considered, students who write with a manuscript handwriting style write faster than those who write with a cursive handwriting style (at all grade levels except for the 4thgrade). However, the effect of hand preference,another independent variable of the study, on handwriting speed is not significant ($F_{(1, 314)} = 3.78$, $p > .01$). Even though it is seen that right-handed students write faster than left-handed students according to the mean values included in Table 5, this difference is not statistically significant. Based on these findings, the independent variables of grade level, gender, and handwriting style have separate, significant effects on mean handwriting speeds. When grade level is assigned as a covariate, however, it is seen that grade level and gender jointly have a significant effect on mean handwriting speeds ($F_{(4, 314)} = 3.53$, $p =< .05$), whereas grade level with hand preference ($F_{(4, 314)} = 1.21$, $p => .05$) and grade level with handwriting style ($F_{(4, 314)}$=1.68, $p => .05$) do not have a significant joint effect on mean handwriting speeds.

Discussion

As a result of this study, which was carried out with the aim of examining primary school students' handwriting speeds according to somevariables, it was concluded that 4th–8th grade students' mean handwriting speeds differed significantly depending on grade level, gender, and handwriting style, whereas they did not differ significantly according to hand preference.

The research findings reveal that primary school (4th–8th grade) students' handwriting speeds differed significantly depending on their grade level. With respect to the multiple comparison test, the difference between all the other grades was significant except forthe difference between the 6th and 7th grades, and the 7th and 8th grades, whichdid not differ significantly regarding their handwriting speed. These differences according to grade levels can be interpreted as an indication that students' writing speed development is linear as well as the fact that writing tasks at secondary school level are mostly being replaced by test and exam mindsets with less focus on writing.This also emphasises the importance of the attention paid by primary school and classroom teachers on the development of writing skills because when children reach the age of 8–10, their handwriting skills usually become automatic, and they can be used as a tool to organise their ideas well and facilitate the development of their thoughts (Julius et al., 2016). The primary school level is critical to achieve this and to acquire the ability to read and write at an appropriate writing speed. The significant difference in students' handwriting speeds in terms of grade level shows similarity with some previous studies (e.g., Graham et al., 1998; Hamstra-Bletz&Blote, 1990; Phelps, Stempel, & Speck, 1985; Skar et al., 2021; Ziviani,1984). In the study by Graham et al. (1998), in which they examined the mean handwriting speeds of 900 students between the 1st and 9th grades, it was reported that the handwriting speed showed a tendency to increase from one grade to the next. In a longitudinal study by Hamstra-Bletz and Blote (1990), in which they conducted five copying activities with 127 Dutch children in three groups, it was reported that between the2ndgrade and 6thgrade, students' mean handwriting speeds increased from 24 letters to 66 letters per minute. In a cross-sectional study conducted by Phelps, Stempel, and Speck (1985) in the USA, 1365 children were required to copy a paragraph in their own handwriting with a pencil onto unlined paper for a period of 2 minutes, and it was seen that there were significant differences in mean handwriting speeds from the 3rdgrade (25 letters per minute) up to the 8thgrade (72 letters per minute). In Australia, Ziviani (1984) conducted a cross-sectional study with 575 children who copied expressions such as "cat and dog" for a period of 2 minutes "as quickly as possible," and it was determined that between the3rdgrade and the 7thgrade, the mean handwriting speeds increased from 33 letters to 52 letters per minute and that this increase was also linear. On the other hand, the finding in the present study that handwriting continued to increase between the 6th, 7th, and 8th grades whereas the difference was not significant corresponds with the results of the study by Graham and Weintraub (1996), in which it was stated that the relationship between handwriting speed and grade level might not always be linear. Similarly, as a result of the study carried out by Türker and Tunç (2020), it was reported that the mean handwriting speeds of 3rdand 4thgrade primary school students did not differ according to the grade level variable. On the other hand in Tseng and Hsueh (1997) research that's sample group consists 1525 Chinese student between 2nd to 6th grade, pointed that speed of handwriting increase with age and reach its highest level especially at 2nd, 3rd and 4th grades. This may be due to morphological features of Chinese. According to Akyol (2008) the impact of the first years of writing learning on handwriting speed is great.Although languages such as Italian, Spanish, and Turkish are transparent, the fact that the spelling rules are easier in Turkish can provide more advantages to students in the writing process in the coming years (Jimenez & Hernandez-Cabrera, 2019).

According to the findings in the current study, primary and secondary school (4th– 8th grade) students' mean handwriting speeds showed significant differences in terms of gender. This result is in favour of female students. This situation suggests that male students should be supported more in order to be able to write at the appropriate speed in writing tasks starting from the pre-school period because unless they can master basic handwriting acquisition, they may be inadequate in writing processes that require high-level cognitive processes, such as planning what to say and how to say it, translating ideas into written text, and reviewing what has been written (Fogel, Rosenblum, & Barnett, 2022).Although the differences regarding gender that were found in this present study are supported by some previous studies in the literature (e.g., Aydın, 2016; Graham, et al., 1998; Skar et al., 2021; Temur, Aksoy, & Tabak, 2012), they differ from the findings of other studies (e.g., Bay, 2010; Türker & Tunç, 2020; Ziviani & Watson-Will, 1998). In his study related to the handwriting speeds of 9th grade students who had learnt first literacy with cursive writing, Aydın (2016) concluded that female students' mean handwriting speeds were higher than those of male students in both handwriting styles (manuscript and cursive). Moreover, in their study in which they examined the mean handwriting speeds of 900 students from the 1stgrade up to the 9thgrade, Graham et al.(1998) revealed that there was a significant difference between male students' and female students' mean handwriting speeds and that

female students in the 1st, 6th, and 7th grades wrote faster than male students. Similarly, in their study, Temur, Aksoy, and Tabak (2012) examined 1st grade students' ergonomic factors in handwriting together with the handwriting speed, and as a result, it was stated that girls' handwriting speed was greater than that of boys. In a study examining the effect of the direction of drawing letter lines on handwriting speed and the quality of letter drawing in 1st, 2nd, 3rd, and 4th grade primary school students, Başaran (2020) stated that female students drew letter lines faster than male students. On the other hand, in a study carried out with students attending the 1st grade, Bay (2010) determined that there was no significant difference in mean handwriting speeds between female students and male students. As a result of the study by Ziviani and Watson-Will (1998), in which they examined the mean handwriting speeds and text legibility of 372 children aged 7–14, it was reported that there was no significant difference between genders with respect to mean handwriting speeds. Based on the formation of handwriting skills specific to each gender, it can be said that female students are developmentally better in fine motor skills than male students (Unutkan, 2006; Başaran, 2020), and this also has an effect on handwriting speed.

The findings in the study also revealed that primary and secondary school (4th–8th grade) students' mean handwriting speeds differed significantly in terms of handwriting styles. Among the reasons for this situation, it can be thought that students in Turkey do not want to continue with cursive handwriting after primary school, that cursive handwriting is challenging/hard for them, and that they prefer manuscript handwriting with the influence of branch teachers. On the other hand, when grade level was treated as a covariate, whether students used cursive or manuscript handwriting did not have an effect on their mean handwriting speeds. Studies conducted about the effect of handwriting style on handwriting speed can be discussed as studies in which the results were in favour of manuscript letters, such as the present study, and studies in which they were not. For example, in his study examining the handwriting speeds of 9th grade students who had learnt first literacy with cursive writing, Aydın (2016) revealed that students who wrote with manuscript letters had higher handwriting speeds over a one-minute period than students who used cursive handwriting. In the study by Morin, Lavoie, and Montésinos-Gelet (2012), in which they examined letterwriting, wordcopying, and textcreation skills over a 45-minute period in 715 Canadian 2nd grade primary school students who learned literacy with different handwriting styles, it was reported that the mean handwriting speeds of students who used mixed and manuscript handwriting styles had greater mean handwriting speeds than those who used cursive handwriting. In their study, Bara and Morin (2013) examined 4thand 5thgrade students' handwriting speed, text legibility, and handwriting style according to the handwriting style they had learnt in primary school, and they stated that Canadian students wrote faster than French students, and students who used a cursive handwriting style had slower mean handwriting speeds than students who used a mixed handwriting style. On the other hand, in the present study, when the joint interaction of grade level was considered, handwriting style did not have a significant effect on mean handwriting speeds. This finding corresponds with the results of the study carried out with 600 students attending 4th–9th grades by Graham, Weintraub, and Berninger (1998), in which the use of cursive and manuscript letters did not make a difference in terms of handwriting speeds.

The findings obtained in this study also revealed that there was no significant difference in primary and secondary school (4th–8th grade) students' mean handwriting speeds with respect to their hand preferences. It did not make a significant difference to mean handwriting speeds if students wrote by using their right or left hand. In studies carried outin relation to the effect of hand preference on handwriting speed, it is striking that there are both similar and different findings. For example, in their study, in which they examined the mean handwriting speeds of 900 students between the 1st and 9th grades, Graham et al. (1998) stated that students who wrote with their right hand wrote faster than students who wrote left-handed, whereas O'Mahony, Dempsey, and Killeen (2008) reported that hand preferences (right or left) of 607 male and 617 female students, with ages ranging between 8 and 18, had no effect on handwriting speed. Similarly, when the joint interaction of grade level was taken into consideration in this current study,the fact that there was no significant difference in mean handwriting speeds between students who used their right or left hands is confirmed withthe findings of some experimental studies (Benik, 2018; Bonoti et al., 2005; Kadıoğlu, 2012; O'Mahony, Dempsey, & Killeen, 2008; Türker&Tunç,2020; Wallen& Mackay, 1999). This situation reveals that in the primary school education process in Turkey, students should not be forced to use their right hand in the first literacy process sinceusing their right hand or left hand does not affect their handwriting speed.

When the studies are evaluated in general, it is seen that there are differences between the effects of the variables of grade level, gender, hand preference, and handwriting style on mean handwriting speedsamong countries. On the other hand, the findings of this study clearly show that mean the handwriting speeds of Turkish students increase according to grade level and vary according to gender as well ashandwriting style. This situation reveals that handwriting speed is a skill that changes and continually develops

together with age, the handwriting style used in the first literacy process should be chosen carefully, and possible effects of differences between genders need to be monitored.In the learning and teaching process, students are given dictation exercises, copying tasks, or writing tasks aimed at producing content-based text. This study of writing speed may contribute to teachers in having more realistic expectations from students about the time required to complete writing tasks. Thus, teachers can have an idea about planning more effective writing activities at more appropriate times. In addition, the areas reserved for writing activities in coursebooks and workbooks can be arranged more appropriately by considering the results for writing speed according to grade level.

Limitations of the Research and Future Directions

This study is limited to 322 students attending the 4th–8th grades of primary and secondary schools in the provinces of Ankara, Trabzon, and Giresun and to the variables of grade level, gender, hand preferences, and handwriting styles for students'mean handwriting speeds. Moreover, to seta common task standard for all students in the study, an informative text was used.

Concerningthe differences in the findings for writing speed,variables such as the individual differences of the students, the number of students participating in the sample, the time, the language characteristics of the country, and the use of different words or texts may be effective (Temur, 2012). In addition, it is stated that the time required to write a letter varies according to the shape and size of the letter, and since the shapes of some letters are easier to produce because they are simple, the writing time of each letter is not equal (Güneş, 2016). Writing is a skill that requires gross and fine motor skills and should be supported in early childhood through play-based learning environments and lessons such as physical education (Patiño et al. 2020).In addition to these, it can be said that the method used to measure the writing speed (dictation or copying) is one of the factors that causes differences in writing speed. Because in a longitudinal study conducted by Gosse, Parmentier, & Van Reybroeck, (2021) with primary school 2nd,3rd,4th and 3rd,4th,5th graders, each child was given a digital tablet and a digital pen to complete a writing task (dictation). As a result of the study, they reported that handwriting speed was associated with high spelling ability and that fast handwriting was detrimental to handwriting quality. Thus, while a positive relationship was found between spelling and speed, a negative relationship was found between handwriting speed and handwriting quality. Moreover, it is seen that the studies conducted in Turkey are with the participation of one or two grade levels. However, since writingspeed is an important factor worth examining on its own, longitudinal studies with different grade levels are needed.

In this research, students' mean handwriting speeds have been examined according to differentvariables. In future studies to be conducted, legibility skills, students' socio-economic levels, and cognitive and motor factors that are directly and indirectly related to handwriting speed, such as attention deficit and muscle fatigue, can be discussed together with handwriting speed. In this way, whether factors specific to handwriting ability or whether external factors that remain beyond students' control have a greater effect on handwriting speed can be investigatedin these future studies. Furthermore, letter production alongwith motor skills in the development of handwriting skills, the role of primary school, and the effect of teaching students a digital handwriting style on handwriting speed by taking technological developments into consideration can be investigated.

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Appendix

"Located on two continents,Turkey is an idyllic country in which the four seasons are experienced in full. Our country is surrounded by seas on three sides, and generously offers you lovely, sun-drenched beaches. It is extremely rich in terms of its vegetationcover and animal species. These lands seem always to re-live the past with their mosques, churches, statues, palaces, and madrasas."

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Validation of a Scale to Assess Activities of Daily Living at Home in Children and Adolescents With Autism Spectrum Disorder

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Abstract

Daily living skills may affect repetitive behavior patterns in individuals with autism spectrum disorder (ASD). This study aimed to validate a scale to assess activities of daily living at home (SAADL) in children and adolescents with ASD. Content validity by expert judgment showed Aiken V values between 0.75 and 0.88. The exploratory factor analysis (EFA) showed factor loadings (0.62 to 0.89) and high communalities. The % explanation of variance for dimension 1 (personal care) was 51.5% and for dimension 2 (mobility in the home) was 66.3%. The Cronbach's reliability was 0.87 and the retest values reflected high values of precision and accuracy. The SAADL is valid and reliable and can be used to assess activities of daily living of self-care and mobility at home.

Keywords:

Activities of Daily Living, Autistic, Validity, Reliability, Scale.

Introduction

Activities of daily living (ADLs) are essential and routine tasks that most young, healthy people can perform without assistance (Edemekong et al., 2020). They are characterized by performing fundamental tasks to support participation in school, home, and community settings in diverse populations (James et al. 2014).

ADLs according to the literature are classified as basic and instrumental activities (Edemekong et al. 2020; Law et al. 2005); "Occupational Therapy Practice Framework: Domain and Process (3rd Edition)" 2017). The former refers to activity-oriented personal tasks such as: walking independently, ability to feed oneself, selecting and putting on appropriate clothing, ability to bathe, groom oneself, maintain personal hygiene, control bladder function, and ability to go to and from the toilet.

Meanwhile, instrumental activities have to do with those that require more complex thinking skills. These include organizational activities such as transportation and shopping, managing finances, shopping, food preparation, managing communication, medication management.

Research currently suggests that many people with autism spectrum disorder (ASD) have impairments in daily living

skills relative to their cognitive skills (Bal et al. 2015; Farley et al. 2009; Marsack-Topolewski et al. 2021). Therefore the assessment of functional impairment, including different areas of a person's life, such as education, family, social life, work life, leisure and free time are crucial, both for the diagnosis, as well as for the therapeutic approach of young people with ASD (Rotger et al. 2014).

In general, levels of functioning, measures of adaptive behavior, and in particular daily living skills, are the variables that most affect repetitive patterns of behavior in people with ASD (Farley et al. 2009; Vahia, 2013). In fact, most people with ASD remain at home with their families until they enter adulthood, so parents provide continuous support to their children to overcome daily living difficulties (ADLs) (Dudley et al. 2019; Marsack-Topolewski et al. 2021).

In addition, in recent months, following the COVID 19 pandemic, children, adolescents and adults with ASD have been locked in their homes for more than a year, so ADLs at home could undergo substantial changes.

Therefore, to assess these daily activities at home it is necessary to have a simple, brief and easy to apply instrument. Therefore, this study aimed to validate a scale to assess activities of daily living (ADLs) within the home of children and adolescents with ASD.

Methodology

Type and sample

A cross-sectional study was designed in Chilean children and adolescents with ASD. The sample consisted of 32 boys and 5 girls from public educational institutions in the cities of Talca, Rancagua and Santiago (Chile). The age range ranged from 4 to 20 years old.

The sample selection was non-probabilistic by convenience. All the information about the children and adolescents with ASD was collected through their parents, since they were the ones who answered the survey. The average age of the parents was 36.85±7.61 years. The sociodemographic variables of both the young people with ASD and their parents are shown in Table 1.

Procedures

Parents were contacted via telephone in May 2021. Once contacted, the objective of the research was explained to them. Parents who agreed to participate in the study signed the informed consent. This stage lasted two weeks.

Children enrolled in state special education schools (preschool, primary and secondary) and those living directly with one or both parents were included. Children whose parents did not complete the applied scale and those living with relatives (other than their parents, one or both parents) were excluded. The entire procedure was performed in accordance with the Local Ethics Committee and the Helsinki declaration for human beings.

Validity and reliability of the scale

The SAADL was validated by expert judgment (content validity) and construct analysis, while reliability was assessed by measures of internal consistency and stability (retest).

Content validity was assessed by expert judgment, according to the suggestions described by Wiersma (2001). Six health and education professionals with a minimum of 10 years of professional and research experience in their area were invited to participate as experts. This panel of professionals with extensive experience in ASD reviewed appropriate scale items as described by Schultz (2005)

The SAADL was sent to each of the experts by e-mail. They then evaluated the degree of representativeness, relevance, diversity, clarity, simplicity and completeness of each of the items of the elaborated instrument in an index card. The alternatives presented a scoring scale from 1 to 5 points. Each expert evaluated the SAADL and resubmitted the form for further analysis. In the end, the SAADL consisted of 8 questions and can be seen in appendix 1.

Construct validation was carried out by measuring exploratory factor analysis (EFA), allowing the underlying structure of the data to be determined (Bollen, 1989).

Reliability was assessed by internal consistency, calculating Cronbach's alpha per question and total scale. On the other hand, stability measures (retest) were also used with a 14-day time interval between both measurements. For the second measurement, nine parents were used, representing 24% of the total sample.

Statistics

The normality of the data was verified by the Shapiro-Wilk test. Descriptive statistics were analyzed for frequencies, percentages, range, mean (X), standard deviation (SD), skewness, and kurtosis.

For content validity, Aiken's V (Bulger & Housner, 2007) was used which evaluates the adequacy of the items to the content validity criteria. Higher values of Aiken's V ≥ 0.75 were accepted (Bulger & Housner, 2007).

For construct validity, the exploratory factor analysis (EFA) fit model was considered by adopting the Kaiser Meyer-Olkin (KMO) sample adequacy criteria,

Bartlett's sphericity value was considered to establish the relevance of the factor analysis, Comparative Fit Index (CFI) root mean square error of approximation (RMSEA). The analysis provided the measure of variance explained, factor loadings, communalities and Chi-square approximation. To assess stability measures, the concordance correlation coefficient (CCC) was calculated, using precision (p) and accuracy (A) according to Lawrence and Lin (1989) approach. In addition, the weighted kappa (Cohen, 1968) was calculated to measure the magnitude of agreement between the two scores (test and retest). In all cases, $p < 0.05$ was adopted. The results were processed and analyzed initially in Excel spreadsheets and subsequently in SPSS 18.0 and Med Calc 11.1.0, as appropriate.

Results

The sociodemographic variables of the parents and children are shown in Table 1. Thirty-seven parents were surveyed, corresponding to 51.4% cohabiting families, 40.5% married and 8.1% divorced. The majority of respondents were female (81.1%) and only 18.9% were male. In addition, most of these families lived in urban areas (86.5%) compared to those in rural areas (13.5%). Regarding information on children with ASD, the majority were males (86.5%) relative to females (13.5%). Of the children, 67.7% lived with both parents (67.7%) and 32.4% with their mothers, while 18.9% were only children and 81.1% had one or more siblings.

Table 1.
Sociodemographic characteristics of the sample studied.

Variables	fi	%
Parental Information		
Gender		
Males	7	18.9
Female	30	81.1
Marital Status		
Married	15	40.5
Divorced	3	8.1
Cohabitant	19	51.4
Area where you live		
Urban	32	86.5
Rural	5	13.5
Children Information		
Sex		
Male	32	86.5
Female	5	13.5
Lives with parents		
Both Parents	25	67.6
Mother Only	12	32.4
Father Only	0	0
Number of brothers		
None	7	18.9
1 Brother	15	40.5
2 Brothers	11	29.7
3 Brothers	3	8.1
4 Brothers	1	2.7

Values for the V of Aiken test are presented in Table 2. The values for each question varied from 0.75 to 0.92 while the values for the dimensions were between 0.82 and 0.88. For all of the cases, the values obtained from the judges reflected an agreement of 0.75 to 0.88.

Table 2.
Content validity of the instrument (SAADL) using Aiken's V by question and dimension.

N°	Dimensions/ Items	RP	RE	DI	CL	SI	CO
Personal care							
1	Item 1	0.92	0.83	0.83	0.92	0.88	0.88
2	Item 2	0.88	0.83	0.75	0.79	0.88	0.83
3	Item 3	0.83	0.88	0.96	0.92	0.75	0.92
4	Item 4	0.79	0.83	0.79	0.88	0.88	0.88
	Total	0.85	0.84	0.83	0.88	0.84	0.88
Mobility in the house							
5	Item 5	0.92	0.83	0.96	0.88	0.83	0.83
6	Item 6	0.88	0.83	0.83	0.83	0.83	0.83
7	Item 7	0.83	0.88	0.79	0.92	0.92	0.92
8	Item 8	0.83	0.79	0.71	0.83	0.88	0.88
	Total	0.86	0.83	0.82	0.86	0.86	0.86

Legend: RP: Representativeness, RE: Relevance, DI: Diversity, CL: Clarity, SI: Simplicity, CO: Comprehensibility, T: Total.

The descriptive values of the SAADL are shown in Table 3. Skewness showed values lower than the average (-0.97 to 1.39) while kurtosis ranged from (-1.88 to 2.68). The coefficient of variation in all cases was less than 33% and the values of Cronbach's alpha per question ranged from 0.81 to 0.90 and in the total scale it was $r = 0.87$.

Table 4 shows the factor loadings and communalities obtained after the EFA. The rotated components matrix was obtained through Varimax. The model fit gave the following results: CFI (0.903), RMSEA (0.057), KMO was 0.80, X^2= 165.1 ($p = 0.000$). Factor loadings ranged from 0.62 to 0.89, while communalities were higher than 0.53. Overall, the % explanation of variance of dimension 1 (personal care) reflected 51.5% and dimension 2 (Mobility in the house) 66.3%.

The reliability values analyzed by means of retesting can be seen in Table 5. The DRI was calculated, obtaining CCC values from 0.87 to 1.0, the values of precision (0.96) and accuracy (0.99) were very high, and even the weighted Kappa showed high concordance values (0.74 to 1.0), which guarantee equivalence between both measurements.

Discussion

The results of the study have shown that the scale proposed in this study proved to be valid and reliable for assessing ADLs in the homes of children and adolescents with ASD.

Table 3.

Descriptive analysis of SAADL in children and adolescents with ASD.

No	Questions	Mean	SD	CV	Asymmetry	Kurtosis	Cronbach
1	In personal care for grooming (bathing, washing, combing hair, etc.)	2.7	0.9	33.3	0.65	-1.51	0.813
2	In personal care for dressing, undressing (change of clothes)	2.89	0.9	32.4	0.23	-1.88	0.9
3	In household chores to organize (clothes, utensils, food, other)	2.3	0.7	28.8	2.03	2.68	0.817
4	In household chores to clean the house (sweeping, mopping, washing clothes, other)	2.43	0.7	29.9	1.39	0.44	0.824
5	In mobility inside the house to move around	3.49	0.7	21	1.07	-0.22	0.812
6	In mobility inside the house to get in and out of the bathtub.	3.14	0.9	29.3	-0.28	-1.8	0.816
7	In mobility within the home for getting up and going to bed	3.43	0.8	23.3	-0.97	-0.7	0.809
8	In mobility inside the house when moving around, going up and down stairs, others.	3.49	0.7	21	-1.08	-0.22	0.863

Legend: SD: Standard deviation, CV: Coefficient of variation

Table 4.

Factor loadings and communalities based on exploratory factor analysis.

N°	Questions	Factor loadings		Communalities
		1	2	
1	In personal care for grooming (bathing, washing, combing hair, other)	0.732	0.419	0.71
2	In personal care for dressing, undressing (changing clothes)	0.625	0.546	0.68
3	In household chores to organize (clothes, utensils, food, other)	0.897	0.117	0.82
4	In household chores to clean the house (sweeping, mopping, washing clothes, other)	0.858	0.18	0.77
5	In mobility inside the house to move around	-0.073	0.802	0.65
6	In mobility inside the house to get in and out of the bathtub.	0.409	0.66	0.6
7	In mobility within the home for getting up and going to bed	0.29	0.666	0.53
8	In mobility inside the house when moving around, going up and down stairs, others.	0.273	0.771	0.67

Legend: 1: Personal care, 2: Mobility in the house.

Table 5.

Values that define the concordance between the values of the test and retest of the SAADL.

N°	Questions	CCC	Precision	Accuracy	Weighted Kappa	Standard Error
1	In personal care for grooming (bathing, washing, combing hair, other)	0.93	0.939	0.99	0.84	0.1
2	In personal care for dressing, undressing (changing clothes)	0.951	0.959	0.993	0.9	0.1
3	In household chores to organize (clothes, utensils, food, other)	1	1	1	1	0
4	In household chores to clean the house (sweeping, mopping, washing clothes, other)	0.878	0.91	0.97	0.74	0.13
5	In mobility inside the house to move around	0.878	0.906	0.97	0	0
6	In mobility inside the house to get in and out of the bathtub.	1	1	1	1	0
7	In mobility within the home for getting up and going to bed	0.905	0.932	0.971	0.85	0.13
8	In mobility inside the house when moving around, going up and down stairs, others.	0.878	0.906	0.97	0.74	0.13
	Scale Total	0.95	0.959	0.99	0.74	0.13

Legend: CCC: concordance correlation coefficient

Two validation techniques (content and construct) were used in this study. First, it was validated by expert judgment, where the results reported by the judges highlight broad homogeneity among the experts' responses. This consensus guarantees the criteria of relevance, diversity, clarity, simplicity and comprehensiveness of the scale as suggested by Wiersma (2001). The questions or items of the scale are adequate and exhaustive, allowing to capture the true attributes that measure ADLs in children and adolescents with ASD.

In fact, the V Aiken values have reflected values above 0.80, which are consistent with other studies (Bolivar-Paredes & Villanueva-Ruska, 2017; Gomez-Campos et al. 2021; Lagos-Luciano et al. 2019). Moreover, they exceed the values of 0.70 described in the literature as adequate values (Charter, 2003) and even, the inter-judge reliability standard is higher than 0.75, which are considered excellent (Cicchetti, 1994).

Secondly, the validation by AFE revealed two dimensions, personal care and mobility at home. In addition, the model was stable and met the criteria for goodness-of-fit indices in CFI, RMSEA, KMO, % variance explanation as described in the literature (Dini et al., 2014; Hu & Bentler, 1999; Schermelleh-Engel, Moosbrugger, & Müller, 2003).

On the other hand, the factor loadings obtained in this study were higher than 0.62, while the communalities >0.53, reflecting acceptable values between item and dimension (Fabrigar et al. 1999; Knekta et al. 2019; MacCallum et al. 2001). These values are similar to those reported in recent studies in youth with ASD (Cassidy et al. 2021; Zhou et al. 2017).

Regarding reliability, data were analyzed by internal consistency and retest. For the first case, Cronbach's alpha was used evidencing high reliability values r = 0.87, being similar to other studies conducted in ASD populations (Breidbord & Croudace, 2013; Brugha et al. 2020; Skuse et al. 2005). In general, the scale proposed here reflects internal consistency among its items according in line with what is suggested in the literature (Nunnally, 1994; Streiner, 2003), highlighting a minimum of 0.80.

In the second case, the retest was used as a measure of stability. The scale was applied to the parents on two occasions with an interval of 14 days, in which it is proposed to consider between 10 and 14 days (Terwee et al. 2007). This time interval has allowed reporting concordance between both measures and high levels of precision and accuracy. This shows that the scale presents stability in the scores of both tests, so they remain without substantial changes when measured on different occasions (Michalos, 2014). In addition, the values obtained in this study are consistent with research that has evaluated reliability by retesting (Berthoz & Hill, 2005; Dutil et al. 2017; Pereira et al. 2008). Re-testing (test and re-test) as quality control criteria for scales in general are crucial, especially if the scales are intended to be applied in treatment interventions. This is because instruments are required to be stable in their results, especially in scales that have to do with ADLs (Dutil et al. 2017).

In general, this study presented some limitations that deserve to be clarified. A relatively small sample was used, and the scale was applied in COVID-19 pandemic time, through google drive. Probably, these factors could have affect the results obtained in the study. However, despite this, the validity and reliability techniques have shown consistent results. It is even one of the first studies that seeks to propose a new scale to be used in the ASD populations that can serve as a baseline for comparing post-pandemic ADLs. It is suggested that future studies expand the study sample, apply other validity and reliability techniques to achieve external validity of the scale.

Conclusion

This study concludes that the SAADL for children and adolescents with ASD is valid and reliable. These psychometric properties warrant its use and regular application to assess daily activities of self-care and mobility in the home in youth with ASD. For the ability to perform ADLs at home can serve to improve safety conditions, greater participation in the home, alleviate family or caregiver overload, and improve their quality of life.

Disclosure statement

The authors reported no potential conflict of interest.

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Appendix 1

Scale to assess activities of daily living at home in children and adolescents with autism spectrum disorder

Part 1. Sociodemographic data of parents:

Date of Birth: ____/____/_____

Marital status: Married ( ) Single ( ) Widowed ( ) Divorced ( )

Area where you live: Urban ( ) Rural ( )

Part 2. Sociodemographic data of the child, adolescent, young person.

Date of birth: ____/____/ _____ Sex: Male ( ) Female ( ).

Lives with: Father ( ) Mother ( ) Both ( ) Other relatives ( ).

Has brothers: 1 ( ) 2 ( ) 3 ( ) >4 ( ).

n	Questions	Independently	With supervision	With assistance (support)	With full support
1	In personal care for grooming (bathing, washing, combing hair, shaving)	4	3	2	1
2	In personal care to get dressed and undressed	4	3	2	1
3	In household chores for shopping (clothes, food...)	4	3	2	1
4	In household chores to clean the house (sweeping, mopping, etc.)	4	3	2	1
5	In mobility within the home to move around	4	3	2	1
6	In mobility inside the house to get in and out of the bathtub.	4	3	2	1
7	In mobility inside the house for getting up and going to bed	4	3	2	1
8	In mobility outdoors to go up and down stairs	4	3	2	1

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Use of an eBook for Oral Health Literacy© Curriculum to Elicit Functional Health Knowledge, Decision Making, and Goal Setting Among School-Aged Children

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Abstract

An eBook for Oral Health Literacy© curriculum was used as a brief intervention to help school-aged children use their functional health literacy skills of reading, writing, and speaking to learn about oral health hygiene and the importance of choosing healthy food and beverages for their teeth. The curriculum focused on building functional knowledge about oral health hygiene and nutrition behaviors through a health literacy intervention that highlighted the need for reasoned actions when setting food goals for healthy teeth and making decisions to keep teeth healthy and strong. The aims of the study included: 1) determining what children learned about their teeth from two chapters of the eBook for Oral Health Literacy© curriculum and what they remembered from reading the oral health and nutrition stories; 2) determining whether children liked to read and what they liked about the words and the pictures of the stories, and; 3) determining whether children brushed their teeth in the morning and at night; had any cavities; had teeth or mouth pain; and visited the dentist every six months for a dental checkup. The visual textual narrative helped children to build a vocabulary about oral health when reading and writing about health. Children wrote about words and phrases that they recalled after reading each chapter. Their elaborations exemplified the importance of using a constructivist theoretical framework to elicit children's functional health knowledge about oral health and nutrition. Chi-square results showed that there was a moderate significant correlation between children who reported brushing their teeth in the morning and having been to the dentist in the past year (p = .021).

Keywords:

Oral Health Literacy, Nutrition, Health Education, Curriculum, Functional Health Knowledge, Functional Health Literacy

Introduction

Childhood dental caries are a preventable global issue that affects more than 600 million children annually (Tinanoff et al., 2019; Ramos-Gomez et al., 2020). Preventive approaches for tooth infections (e.g., dental caries) have included health education, regular dental checkups, better nutrition (Sharma et al., 2022), and school sealant programs

KURA group

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(Griffin et al., 2017; Griffin, et al., 2016; Griffin et al., 2014). However, dental caries and gum inflammation do not only affect the mouth. A recent Oral Health report from the National Institute of Dental and Craniofacial Research (NIDCR, 2021) indicated that more than 50 systemic diseases begin in the mouth and contribute to lifelong chronic disease. Oral health promotion and disease prevention interventions are necessary across the lifespan because the prevalence of disease increases with age (NIDCR, 2021).

Oral Health Education

Lack of resources such as access to a toothbrush, toothpaste, floss, or dental checkups are critical issues that have not been adequately addressed for children in the U.S. (Brown et al., 2006). To date, public health plans to reduce dental caries in children include advocating for fluoridated water in community water supplies, imposing a sugar tax on high-caloric foods, increasing health literacy initiatives, implementing more dental services in school-based health clinics (Arenson et al., 2019), and changing the age of the first dental visit to one-year old to help children start school healthier (American Academy of Pediatrics, 2003). Because education predicts health literacy by 18% with health literacy serving as a mediator between socioeconomic status and health (Lastrucci et al., 2019), oral health education programs are essential in schools to give children of all socioeconomic backgrounds affordances to maximize their health and wellbeing. Results from the 2016 School Health Policies and Practices Study (CDC, 2017) indicated that 57.7% of school districts had adopted a policy stating that their elementary schools will teach oral health. As a result, health education curricula need to take a skill-based approach through decision making and goal setting in order to educate children on the oral health behaviors they can practice every day to become healthy (Ubbes et al., 2020a; Ubbes & Witter, 2021).

For school-aged children, proper dental hygiene and nutrition education can support cognitive development, school readiness, self-esteem, and a longer quality of life (Ramos-Gomez et al., 2020). Midstream influencers of children are elementary teachers and parents who can help to identify the underlying reasons for poor school attendance from dental pain (Jackson, et al., 2011). For example, missing school contributes to poor academic attendance by children (Eklund et al., 2022), which can affect academic performance in the form of overall test scores. And unfortunately, tooth pain can reduce children's ability to focus on classroom learning and homework completion when they are in school (Ruff et al., 2019). Untreated dental caries can cause pain and infection and ultimately lead to problems in eating, speaking, and learning (NIHCD, 2021).

Health Literacy

Health literacy has been defined as functional, interactive, and critical (Nutbeam, 2000) with more recent recommendations to "define health literacy in the context of quality school health education" and to "support school health education as a strategic avenue to achieve health literacy" (Videto & Dake, 2019). The Institute of Medicine's (IOM) report entitled Health Literacy: A Prescription to End Confusion stated that the "most effective means to improve health literacy is to ensure that education about health is a part of the curriculum at all levels of education" (Nielsen-Bohlman, Panzer, & Kindig, 2004, p. 149).

When considering health literacy for early childhood, the health literacy of a child's parents (or primary caregivers) is considered to be the most important because low parent and caregiver health literacy are linked to poorer health-related knowledge, behaviors, and health outcomes of their children (Morrison et al., 2019). Velardo and Drummond (2017) have advocated for child centric approaches in health literacy research and "the importance of working with children" (p. 9). This includes the need for school-based health literacy (p. 10) to include easily accessible health information that can be understood by younger age groups. There has also been a call to action on "understanding children's needs by including children as active participants in research....with the goal of understanding how children construe their social worlds" (p. 9) and how "children make sense of health messages" (p. 7).

Theoretical Framework

A constructivist theoretical framework in health education aims to teach concepts that focus on patterns and relationships in health-related information while encouraging students to take an active collaborative role in their learning by making meaning and constructing their own understanding and inferences about health (Ubbes et al., 2009). Children learn about health through the influence of their families and peers in a social context (Vygotsky, 1978). Making meaning of concepts related to health promotion and disease prevention requires the practice of functional health literacy skills (e.g., reading, writing, speaking) in order to build functional health knowledge at a foundational level in health education. Tappe et al. (2009) define functional knowledge as specific concepts and information that students need to know in order to engage in healthy behaviors. More recent descriptions of functional health knowledge includes "valid and reliable information and concepts that support health beliefs, skills, and behaviors" (National Consensus for School Health Education, 2022, p. 20).

Oral health literacy curricula are available to encourage elementary children to brush their teeth with fluoridated toothpaste twice a day, floss their teeth to reduce gum inflammation, eat healthy foods and beverages, and get a dental checkup every six months while building their functional health literacy skills (Ubbes et al., 2020a; Ubbes & Witter, 2021). If children do not brush their teeth and practice poor oral hygiene habits, plaque will build up on the surface of the tooth and cause the tooth to decay as evident by changes in oral bacterial flora (Butera et al., 2022).

Purpose of the Study

The eBook for Oral Health Literacy© curriculum was implemented with elementary children to teach them how to set goals and make decisions about their oral health hygiene and nutrition. The main goals of the study were: 1) determining what children learned about their teeth from two chapters of the eBook for Oral Health Literacy© curriculum and what they remembered from reading the oral health and nutrition stories; 2) determining whether they liked to read and what they liked about the words and the pictures of the stories; and 3) determining whether children brushed their teeth in the morning and at night; had any cavities; had mouth pain; and visited the dentist every six months for a dental checkup.

Method

Participants

Participants (*n* = 39) included a convenience sample of second grade (*n* = 21) and third grade (*n* = 18) students from a city school district in the Midwestern United States. Children were from intact classrooms in two different elementary schools from the same school district. Gender breakdowns for the participants (*n* = 39) included 19 girls, 18 boys, and 2 did not specify their gender. Second grade students (*n* = 21) read Chapter 6 of the curriculum called "Decisions to Keep My Teeth Healthy and Strong". Third grade students (*n* = 18) read Chapter 6 and also read Chapter 5 of the curriculum called "Setting Food Goals for Healthy Teeth".

Procedures

This pilot study assessed second and third grade children (*n* = 39) on their oral health vocabulary recall after reading and listening to the narration of two chapters of the e-Book for Oral Health Literacy© curriculum, specifically from Theme 2 entitled "Oral Health and Nutrition of Children". Classroom instruction at the elementary schools was led by a faculty member from the local university, who was a registered dietitian and instructor of a senior-level nutrition course. Chapters 5 and 6 were read by the elementary students who advanced the slides at their own pace using their computer mouse. Each chapter took one minute to read and then the children were asked to recall and write what they had learned from the e-Book chapters through an open-ended conversational process. Third graders (*n* = 18) read Chapters 5 and 6 of the curriculum whereas second graders (*n* = 21) read only Chapter 6 of the curriculum. Students responded to the survey questions that are explained below.

Survey Questions

There were two types of surveys for the elementary children. Children responded to four open-ended questions: What is something that you learned about your teeth today? What is something you remember about the pictures in the book? What is something you remember about the words in the book? What did you like about the book that you read? Children also responded to six multiple choice questions: (1) Did you brush your teeth this morning? (Yes, I did!; No, I did not.); (2) Have you been to the dentist in the last year? (Yes; No); (3) How many cavities (or fillings) do you have in your teeth? (Open ended response); (4) Have you ever missed school because your teeth or mouth hurt? (Yes; No); (5) Do you like to read? (Yes, all of the time!; Sometimes; No, not really); and (6) Gender.

Curriculum Materials

The eBook for Oral Health Literacy© is a theory-based intervention that encourages students to read about decision-making and goal-setting messages for improving their oral health and nutrition behaviors in tandem. The curriculum and supportive materials are found on the Digital Literacy Partnership website at Miami University (Ubbes & Miami University Libraries, 2022). The eBook for Oral Health Literacy© has been previously evaluated for its readability, suitability, understandability, actionability, and gist-based message design (Ubbes, et al., 2020) including eye tracking feedback from three audiences (Ubbes, et al., 2018c). The primary prevention curriculum with five themes was designed and targeted directly to children in order to shape their health-related beliefs, skills and, behaviors regarding oral health and nutrition practices in their everyday life. Overall, 17 chapters include visual-textual-gestural storylines that demonstrate healthy actions for brushing, rinsing, flossing, and going to the dentist for a 6-month checkup, including eating nutrient-dense foods and beverages. For the purposes of this study, only Chapters 5 and 6 of the curriculum were selected as a brief intervention in the elementary classrooms. Chapters 5 and 6 represented one curriculum theme with two synergistic health behaviors: oral health and nutrition.

Figure 1 shows the Cover Page of Chapter 5, entitled "Setting Food Goals for Healthy Teeth". Chapter 5 encourages children to improve the health of their teeth by setting fresh food goals every day.

The following polysyllabic vocabulary words are integrated into 10 different sentences on 10 slides: yogurt, fibrous, fiber, remove, sugar, eating, visit, dentist, healthy, toothpaste, buying, evening, watching, brushes, improve, healthy, calcium, and grocery. Main generalizations and phrases of the chapter include: Set a food goal to improve the health of your teeth by eating healthy meals. Eat yogurt because calcium helps your teeth to grow strong. Eat fibrous fresh foods to remove plaque and sugar from your teeth. Brush your teeth after snacks and meals.

Figure 1.
Cover Page of Chapter 5 "Setting Food Goals for Healthy Teeth"

Figure 2 shows the Cover Page of Chapter 6, entitled "Decisions to Keep My Teeth Healthy and Strong". Chapter 6 focuses on food decisions for healthy and strong teeth. The following polysyllabic vocabulary words are integrated into 10 sentences on 10 slides: healthy, eating, drinking, morning, apples, candy, water, soda, sugar, decisions, vegetables, broccoli, calcium, nutritious, beverages, and family. Main generalizations and phrases include: Decide to keep your teeth healthy and strong. Eat your vegetables like broccoli because broccoli contains calcium for teeth. Drink your milk at lunch and at home. Eat apples instead of candy. Drink more water instead of sugary soda because water can rinse and clean your teeth and gums.

Figure 2.
Cover Page of Chapter 6: "Decisions to Keep My Teeth Health and Strong"

Data Analysis

Data analysis was conducted using SPSS Version 25 (IBM Corporation). Significance was set at $p \geq 0.05$. For the Chapter 5 multiple choice questions, Shapiro-Wilk normality tests were performed to evaluate the type of correlation needed. Spearman rank order correlations were run because the data were skewed and thus, a non-parametric statistic was needed. The non-parametric Chi-square statistic, was used to analyze group differences because the dependent variable was measured at a nominal level (McHugh, 2013). For the Chapter 5 multiple-choice questions, several statistical tests were run, including frequencies, Shapiro-Wilk normality, Spearman rank order correlations, and a Chi-square test. Chapter 6 involved open-ended written responses and elaborations and did not require statistics.

Results

Six multiple choice questions formed the basis for our second and third research goals. Frequency results for the question, "Did you brush your teeth this morning?", 15 students selected, "Yes, I did!" and 3 selected "No, I did not". For the question, "Have you been to the dentist in the last year?", 17 said "Yes" and 1 selected "No". A test of Shapiro-Wilk normality for all six variables was run from the Chapter 5 multiple choice questions (n = 18). The 6 variables were: Did you brush your teeth this morning?; Have you been to the dentist in the past year?; Gender; Have you ever missed school because your teeth hurt?; How many cavities (or fillings) do you have in your teeth?; and Do you like to read? One of the reasons that the data were not normally distributed was because it is difficult to have high variability when the number of participants were less than fifty. The normality test was run in order to determine the proper correlation test that should be used for further testing of the data. If the data were normally distributed, a Pearson product moment correlation would have been run; however, the data were skewed, so a nonparametric Spearman correlation was run. All the variables were considered not normally distributed as the significance values were all less than 0.05. According to a source, "The Shapiro–Wilk test is a more appropriate method for small sample sizes (<50 samples) although it can also be used on larger sample size while Kolmogorov–Smirnov test is used for n ≥50" (Mishra et al., 2019, p. 70).

Table 1 shows the results of the Spearman rank order correlations for Chapter 5 Multiple Choice questions with six variables. The two questions, "Did you brush your teeth this morning?" and "Have you been to the dentist in the last year?" were significant (p = 0.020). The correlation coefficient was 0.542 which shows that there was a moderate, positive relationship between the two variables, r(16)= 0.542, p = 0.020, because the higher the correlation coefficient, the stronger

the relationship. No other values had significant correlations because their *p*-value was ≥ 0.05.

Table 2 represents Chi-square results for the variables, Did you brush teeth in the morning? and Have you been to the dentist in the last year? The Pearson Chi-square test was run in order to test if the variables were associated with each other. Results for the Pearson Chi-square test indicated a 5.294 value with a two-sided p-value of 0.021. Because the p-value is less than the significance level of p<0.05, the relationship between these two variables was significant. In other words, morning teeth brushing and going to the dentist in the last year were associated with each other.

Table 1.

Spearman Rank Order Correlations for Chapter 5 Multiple Choice Questions

Multiple Choice Questions		Did you brush your teeth this morning?	Have you been to the dentist in the last year?	How many cavities (or fillings) do you have in your teeth?	Do you like to read?	Have you ever missed school because your teeth hurt?	Gender
Did you brush your teeth this morning?	Correlation Coefficient	1.000	.542*	.052	-.123	.108	-.100
	Significance (2-tailed)		.020	.839	.626	.668	.693
Have you been to the dentist in the last year?	Correlation Coefficient	.542*	1.000	-.168	-.301	.059	-.217
	Significance (2-tailed)	.020	.504	.224	.817	.387	
How many cavities (or fillings) do you have in your teeth?	Correlation Coefficient	.052	-.168	1.000	-.070	.168	.155
	Significance (2-tailed)	.839	.504		.781	.504	.539
Do you like to read?	Correlation Coefficient	-.123	-.301	-.070	1.000	-.351	.278
	Significance (2-tailed)	.626	.224	.781		.153	.264
Have you ever missed school because your teeth hurt?	Correlation Coefficient	.108	.059	.168	-.351	1.000	-.271
	Significance (2-tailed)	.668	.817	.504	.153		.276
Gender	Correlation Coefficient	-.100	-.217	.155	.278	-.271	1.000
	Significance (2-tailed)	.693	.387	.539	.264	.276	

*Correlation is significant at the 0.05 level (2-tailed); n=18

Table 2.

Chi-Square Results for Brush Teeth in the Morning? and Been to the Dentist in the Last Year?

Chi-Square Tests	Value	df	Asymptotic Significance (2-sided)	Exact Significance (2-sided)	Exact Significance (1-sided)
Pearson Chi-Square	5.294[a]	1	.021		
Continuity Correction[b]	.847	1	.357		
Likelihood Ratio	3.905	1	.048		
Fisher's Exact Test				.167	.167
Linear-by-Linear Association	5.000	1	.025		
N of Valid Cases	18				

a. 3 cells (75%) have expected count less than 5. The minimum expected count is .17.
b. Computed only for a 2x2 table.

Figure 3 shows the results for the Spearman rank order correlation between: Did you brush your teeth this morning? and Have you been to the dentist in the last year? (n = 18). All the students that brushed their teeth in the morning had been to the dentist in the past year. Only one student did not go to the dentist in the last year, and that student did not brush their teeth in the morning. This correlation was significant with a p-value of 0.02.

Figure 3.

Bar Graph of Spearman Rank Order Correlation between "Did you brush your teeth this morning?" and "Have you been to the dentist in the last year?"

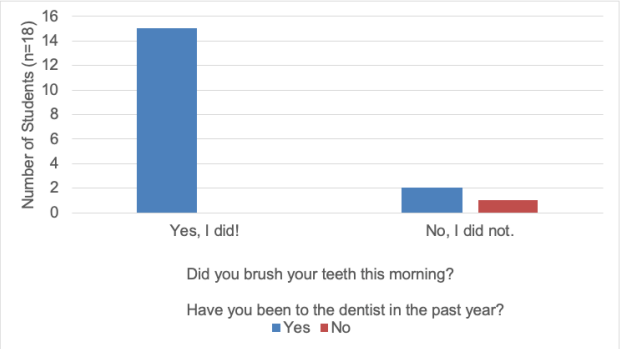


Figure 4 displays the Spearman rank order correlation for the variables, Do you like to read? and Gender? These questions were asked because students had to read and listen to the chapter from the eBook for Oral Health Literacy© curriculum to learn about their oral health. When answering the attitudinal question, "Do you like to read?", 18 participants indicated "Yes, all of the time" (4 girls, 2 boys); "Sometimes" (5 girls, 3 boys); and "No, not really" (1 girl, 3 boys). In general, girls (n = 10) liked to read more than boys (n = 8), but it was not significant.

Figure 4.

Spearman Rank Order Correlation between "Gender?" & "Do you like to read?"

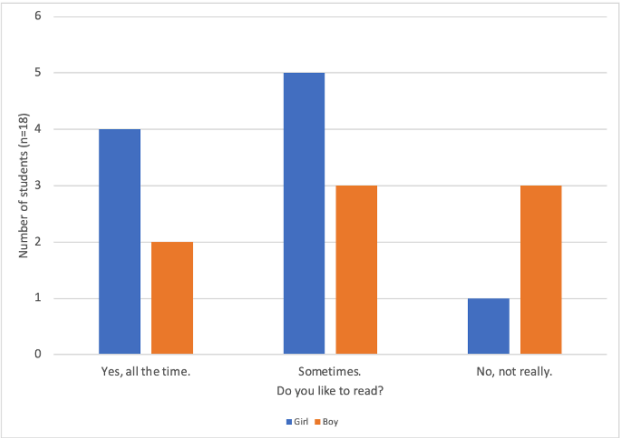
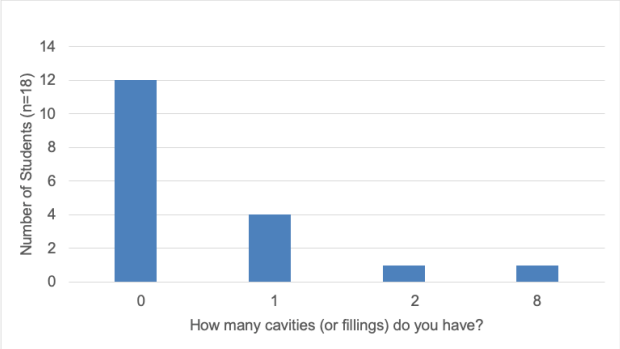


Figure 5 shows the frequency results for the number of cavities that the students self-reported. When asked the question "How many cavities (or fillings) do you have in your teeth?",12 students reported that they did not have any cavities, 4 students reported one cavity, 1 student reported two cavities, and 1 student reported 8 cavities in their teeth. Although not indicated in Figure 5, when students were asked, "Have you ever missed school because your teeth hurt?", only one student answered "Yes" and seventeen students answered "No".

Figure 5.

Bar Graph for "How many cavities (or fillings) do you have in your teeth?"



Results for Chapter Elaborations

Students were encouraged to write their thoughts about the Chapter 5 and Chapter 6 eBook stories. Written responses included vocabulary from the stories and certain phrases they recalled from reading a story one time. The written elicitations from students provided a form of qualitative responses that go beyond the objective multiple-choice responses that they also provided. The results below will explain the Chapter 5 and Chapter 6 vocabulary words and phrases that represented their functional health knowledge, including what elaborations that students remembered about the pictures and words from the book, what they liked about the book, and what they learned about their teeth.

Chapter 5 Elaborations

After reading the Chapter 5 eBook, some of the most frequently reported vocabulary words were: calcium, healthy, dentist, goal, and yogurt. Some students not only listed a singular word but wrote the vocabulary word in a phrase similar to what they read in the book and recalled from their memory. Some examples are "setting goals for brushing and flossing teeth", "going to the dentist every 6 months", "it said I set a goal to eat yogurt which has calcium because calcium helps my teeth to grow strong.", "calcium helps my teeth grow." "set a goal to visit and talk with my dentist every 6 months.", "That fiber and calcium help your teeth stay healthy." These self-reported vocabulary words and phrases were important because the students only read the one-minute story once then recalled and wrote down words that stood out to them or seemed meaningful to them. The data showed that

students were able to draw upon their memory and use a working vocabulary which represented their functional health knowledge from the curriculum.

Chapter 6 Elaborations

After reading Chapter 6 only once, some of the most frequently written vocabulary words were: eating, healthy, dentist, calcium, and yogurt. Other written answers included: decisions, choices, floss, broccoli, brush teeth, and clean teeth. When asked what they learned from reading Chapter 6, the children wrote the following phrases and tips: "do not eat as much sugar"; "eat an apple instead of candy"; "drink lots of water"; "drink milk everyday"; "eat fruits and vegetables." Others said, "When you go to the store buy a toothbrush" and "brush them every day". By asking more open-ended questions for elaborations, students were able to remember key words and phrases which may help them make healthier choices to benefit both their nutrition and oral health. Elaborations indicated that students were able to recall and comprehend basic health information in the form of nutrition and oral health vocabulary words and phrases, which represented their functional health knowledge from the curriculum.

Remembering the Pictures in the Book

When second and third graders (*n* = 39) were asked "What is something you remember about the pictures in the book?", the students wrote: "They all contain kids/adults making good and healthy choices", "Lettuce is good for your teeth.", "A boy eating an apple.", "Brushing teeth and flossing.", "Girl drinking water.", "They all include kids doing healthy choices.", "Someone smiling", "They include nutritious pictures.", "Every picture had a healthy food in it.", "Eating yogurt.", and "They were all doing something about their teeth."

Remembering the Words In the Book

When second and third graders (*n* = 39) were asked, "What is something you remember about the words in the book?", the students wrote: "Floss.", "Fiber.", "Calcium helps my teeth grow strong.", "I buy toothpaste with my mom and floss.", "It said I set a goal to eat yogurt which has calcium because calcium helps my teeth to grow strong.", "Set a goal to visit and talk with my dentist every 6 months.", "Setting goals for brushing and flossing teeth.", "They talk about food that is healthy for your teeth.", "They talk about fruit.", "You need to keep your teeth healthy.", "The words are all about teeth.", "Food goals.", "Milk is healthy for your teeth.", "Fruit is good.", "Nutritious beverages.", "They told us about healthy food.", "Going to the dentist every 6 months.", "Healthy goals.", "Yogurt has calcium.", "When you go to the store buy a toothbrush.", "They all talk about kids making their choices about being more healthy.", "They make healthy goals.", and "They talk about healthy choices."

Remembering What Children Liked About the Book

When second and third graders (n=39) were asked, "What did you like about the book that you read?", the students wrote, "I love my teeth.", "It had vegetables.", "It has healthy tips for you.", "It taught me to do healthy choices, keep my teeth healthy.", "Tips.", "The girl and the mom buying toothpaste and floss.", "The pictures.", "It was cool.", "To set healthy goals.", "I like that it helps me remember brush your teeth.", "It helps you learn how to keep your teeth clean.", "All of it.", and "To help us be healthy."

Remembering What Children Learned About Their Teeth

When second and third graders (*n* = 39) were asked, "What is something that you learned about your teeth today?", they wrote: "Brush every day.", "Calcium helps my teeth grow strong.", "Floss your teeth.", "That fiber and calcium help your teeth stay healthy.", "That you always need to brush your teeth.", "To go to the dentist every 6 months.", "Always floss.", "Brush your teeth to keep them clean.", "Calcium makes your teeth strong.", "Fill in cavities.", "Clean my teeth.", "Go to the dentist every 6 months.", "How to brush your teeth.", "To not eat as much sugar.", and "You can keep your teeth clean if you eat certain foods sometimes."

Discussion

There is an ongoing need to offer more preventative oral health education for U.S. children, especially since 51 million hours of school time are missed annually because of dental-related problems (USDHHS, 2000), and children with fair or poor oral health are 2.8 times more likely to lose greater than one hour of school time compared to children with very good oral health (Naavaal & Kelekar, 2018). Moreover, there are limited empirically tested school-based caries programs with adequate training support for teachers and school staff to ensure fidelity to program implementation (Sharma, et al., 2021). In the current pilot study to investigate the feasibility of introducing the eBook for Oral Health Literacy© curriculum to second and third graders, a dietitian serving as a guest nutrition educator found it easy to implement two chapters in the classroom and build additional content around the stories. Because a lack of oral hygiene and inadequate nutrition are risk factors for systemic diseases that begin in the mouth (NIDCR, 2021), school curricula should promote the integrative connections between oral health, nutrition, and disease prevention in order to boost children's functional health knowledge, skill development, and health behaviors across the lifespan.

The eBook for Oral Health Literacy© curriculum is aligned to the National Health Education Standards with a specific focus on developing decision making and goal setting skills. The National Health Education Standards focus on what students should know and be able to do with an emphasis on demonstrating health-enhancing skills and behaviors to reduce risks, promote health, and prevent disease (Joint Committee on National Health Education Standards, 2007). Results from the 2016 School Health Policies and Practices Study (CDC, 2017) indicated that 77.1% of school districts had adopted a policy stating that their elementary schools will teach decision making, and 69.2% of school districts had adopted a policy to teach goal setting. Decision making is defined as "the ability to select between two or more alternatives to reach the best outcome in a specified time frame. Decision making requires the use of accurate and reliable information while progressing through a set of steps intended to take deliberate actions to enhance health" (National Consensus for School Health Education, 2022, p. 20). Goal setting is defined as "the process of determining a desired health-related behavior or practice to achieve over a specific time period. This process is more deliberate than desires and momentary intentions and involves committed thoughts, emotions, and behaviors toward attaining the goal" (National Consensus for School Health Education, 2022, p. 21).

The National Health Education Standards (Joint Committee on National Health Education Standards, 2007, p. 63) suggested that students in prekindergarten to grade two receive 40 hours of instructional time per academic year which is approximately one hour per week. Instructional time for students in grades three to twelve were recommended to receive 80 hours of instructional time per academic year, which is approximately two hours per week. In the current study, health education was not occurring at all. Therefore, the second and third-grade children in the current study would benefit greatly from 1 to 2 hours of health instruction each week (Joint Committee on National Health Education Standards, 2007). The fact that the eBook for Oral Health Literacy© curriculum only requires one-minute intervals to read in order to instruct children on both their oral health and nutrition behaviors could be a perk for children so they learn more functional health knowledge while also learning health-related skills.

The eBook for Oral Health Literacy© curriculum combines declarative sentences and a vocabulary about oral health and nutrition to teach elementary children about health education concepts and skills. The curriculum focuses specifically on cognitive skill development by underlining the words 'decision making' (Chapter 5) and 'goal setting' (Chapter 6) on each page for promoting children's awareness of these skill-based verbs to help them take personal and social actions toward practicing their oral health hygiene and consuming healthy food and beverages. Questions, cues, and advanced organizers are known to be an evidence-based instructional strategy (Clemons et al., 2010). On each page, underlined cues for the words "decision making" and "goal setting" can also be described as a priming effect, which involves the activation of a mental concept in memory to increase the likelihood that the concept will be used again when processing information (Farrar et al, 2022). Priming effects have been successfully applied in early childhood vocabulary (Avila-Varela et al., 2021). Additionally, the concluding page in each story is intended to be a form of skill-based cuing to provoke further action. Chapter 5 reads "How about you? Will you set a food goal for healthy teeth too?" whereas Chapter 6 reads "I've made the decision to keep my teeth healthy and strong! How about you? Have you made the decision too?". These question cues are an example of interactive health literacy between the writer (narrator) and the reader in first-person narrative. Future research will have to determine the effects of priming on food goals and oral health hygiene behaviors among children exposed to the oral health literacy curriculum.

In the current study, health education instruction by the classroom teacher was limited so the health literacy intervention occurred when a dietitian visited the classroom. In this situation, expertise from the nutrition community helped to promote the importance of nutrient-dense food and beverages in tandem with oral health education which is an example of how to advance community involvement and health education using the Whole School, Whole Community, and Whole Child model (Lewallen et al., 2015). Finding ways to implement the eBook for Oral Health Literacy© curriculum in other places in the school day could be advantageous since children's elaborations showed that they learned and recalled content knowledge in the form of vocabulary and health-related phrases after reading only one chapter (Grade 2) or two chapters (Grade 3).

The vocabulary and linguistic readiness of children to learn a specific domain of health within their academic studies is paramount. Health-related words like decay, infection, cavities, flossing, rinsing, and brushing need to be named and understood (e.g., comprehension) through functional health literacy skills (e.g., reading, writing, and speaking) before children can operationalize or demonstrate their functional health knowledge and skill development toward healthy behaviors. By repeating daily health behaviors each day and practicing the skills leading to the behavior based on feedback from teachers and parents, children can form important habits of health. Research shows that feedback both regulates and is

regulated by motivational beliefs (Nicol & Macfarlane-Dick, 2006). External feedback has been shown to influence how students feel about themselves (positively or negatively), and what and how they learn (Dweck, 1999). Students need to practice oral health patterns every day to meet standards for brushing, rinsing, and flossing their teeth (Thornton et al., 2019; dos Santos et al., 2011). Oral health requires children to learn functional knowledge of what hygiene is (and what it is not) while also demonstrating procedural knowledge of how to do it. Contextual knowledge is also necessary so students know when, where, and to what extent they should practice the oral health behaviors of brushing, rinsing, flossing, AND eating and drinking nutrient-dense food and beverages for healthy teeth.

Written feedback from second and third graders indicated that the eBook for Oral Health Literacy© curriculum may have provided opportunities for students to increase their functional knowledge and vocabulary about oral health hygiene and healthy eating. Students were able to access visual role models on each page to increase their awareness of social norms that lead to healthy behaviors. Students also experienced auditory cues when the story was read to them which aimed to build their understanding of words and how they are pronounced. Children benefit from multimodal educational approaches that integrate visual, textual, auditory, and gestural representations when learning about their health (Ubbes, 2008). The design of the eBook for Oral Health Literacy© even goes beyond multimodal approaches to include multisensory, multigenre, and multidisciplinary elements for teaching about oral health hygiene, nutrition, and dental checkups (Ubbes et al., 2018).

Health educators who learn how to adopt a constructivist pedagogical perspective (Ubbes et al., 2009) will be able to seek out how students are thinking about a topic and reflect on how they make meaning from the lesson. Health education interventions have traditionally focused on knowledge, attitudes, and behaviors in a didactic manner. However, child-centric approaches that adopt elicitations through oral conversations and open-ended written responses may help educators to uncover the motivations and attitudes of children when they are learning skill-based health education. The National Health Education Standards (National Consensus for School Health Education, 2022) focus on skills like interpersonal communication, decision making, and goal setting, to name a few. So, asking students to talk and write about their learning experiences after reading chapters from the eBook for Oral Health Literacy© curriculum can provide insights into how children practice cognitive skills leading to oral health behaviors. Such elicitations can also be aimed at helping children to elaborate on their attitudes, beliefs, and feelings about specific health behaviors like oral health and nutrition. Elaborations through written and spoken conversations can help children to make progress in practicing health-related behaviors which are the key outcome of any health education curriculum, but children can also be taught to explicitly work on two behaviors at once by realizing similar patterns between oral hygiene and nutrition for building healthy teeth, mouth, and gums. With limited time to teach health education in the school day, the curriculum can also extend to home-based implementation around mealtime, nap time, and bedtime routines.

Although the main outcome of a skill-based health education curriculum is healthy behavior (Joint Committee on the National Health Education Standards, 2007), schools can also use literacy time across the curriculum to construct meaning about health. In second and third grade, children build their literacy and reading proficiency by "learning to read". However, by fourth grade, children should have strong literacy skills as they shift toward "reading to learn" more disciplinary content knowledge (Wright, 2019, p.4). According to the Ohio Department of Education (2020), "language and literacy acquisition and achievement [are] foundational knowledge that supports student success". As such, literacy skills should be fully developed at the second and third grade levels so that they may serve as a foundation for further literacy development. The national public health initiative, Healthy People 2030 (USDHHS, 2020), indicates that only 48% of fourth graders read at their grade level in the United States.

Functional health literacy depends on the basic skills of reading, writing, and speaking about health (Ubbes et al., 2018b), so functional health literacy serves as an integrated pathway for learning two disciplines, e.g., literacy and health, at the same time. Although health educators are not responsible for the direct teaching of reading, writing, and speaking in a literacy sense, health educators would be using these functional forms of literacy, albeit functional health literacy, when providing examples of individuals learning about health and how to practice healthy behaviors. Children need to experience and practice these functional forms of literacy across the school curriculum so they can communicate and make meaning when learning about health. Hence, learning to read and reading to learn become symbiotic processes from early childhood into middle childhood and beyond. Therefore, the eBook for Oral Health Literacy© curriculum may be helpful in increasing functional knowledge, vocabulary, and reading proficiency about health, which could result in higher student achievement and lifelong learning. The narration of the chapter stories help children on a developmental

level to be able to learn health education at their own pace as they advance to the next page as assisted by teachers, peers, and/or parents as guides on the side.

Goal 1. To determine what children learned about their teeth from two chapters of the eBook for Oral Health Literacy© curriculum and what they remembered from reading the oral health and nutrition stories

This study not only aims to educate students about oral health habits, but also help to build their healthy literacy skills. One of the multiple-choice questions asks students, "Do you like to read?" About 20% of students said that they do "not really like to read". This could be for several reasons, one of which being that they are not comfortable reading due to a lack of literacy skills. By implementing the eBook for Oral Health Literacy© curriculum, students can learn to build both their health literacy and self-efficacy which would hopefully promote a liking for reading and increase the amount of time spent reading. When looking further into the results if the students like to read, girls generally liked to read more than boys did. When answering the question, "Do you like to read?", four girls versus two boys selected "Yes, all of the time"; five girls versus three boys selected "Sometimes"; and only one girl versus three boys selected "No, not really." Although these findings were not statistically significant when the Spearman rank order correlation was run, there is prior research to build on the idea that girls generally enjoy reading more than boys (Ubbes et al, 2018b).

By allowing children to respond to open-ended questions rather than only multiple-choice questions, they were able to recall what stood out to them as they read the eBook. Open-ended questions also allow teachers and parents better insights into what the children know, feel, and show interest in. Written language is an expressive language that affords teachers and parents insights into what children know and think about, especially when the curriculum is used as a vehicle for sharing new vocabulary words that lead to functional health knowledge. Expressive written language also gives teachers and parents insights into what children are feeling and how motivated they are to practice daily oral hygiene and eating nutritious foods.

For the Chapter 5 eBook, some of the most frequently reported vocabulary words were calcium, healthy, dentist, fruit, vegetable, and yogurt. For Chapter 6 of the eBook, some of the most reported vocabulary words were: eating, healthy, dentist, calcium, and yogurt. Other words frequently reported were goals, decisions, choices, floss, broccoli, brush teeth, and clean teeth.

Based on the children's responses, they were able to recall multiple vocabulary words as well as other words that were mentioned throughout the eBook chapters around the topics of oral health and nutrition. Some of the words used in the chapters might not have been familiar to the children. This forced the children to recall from memory what they had heard, as well as remember the context in which the word was used, in order to spell it out in their open-ended answers. This chain of thought relates to higher order thinking skills. In a different study it was said that "...in its simple form, HOTS (higher order thinking skills) in storytelling was developed in young learners through open-ended question[ing], a strategy which enables students to practice speaking through giving opinion, comment, and imagination while analyzing and evaluating the story" (Setyarini et al., 2018). There are many advantages to using open-ended questions, because questions elicit children to tell a story and practice various ways of thinking. Children who wanted to communicate their thoughts via lists and sentences, had to spell out their ideas (this study) and/or drew an illustration (our first study). A couple of students drew pictures to express what stood out to them; for example, one student drew a picture of a toothbrush. Hence, higher order thinking skills can prompt children to practice functional health literacy as an expressive language for communication.

Goal 2. To determine whether children liked to read and what they liked about the words and the pictures of the oral health stories

This study focused on oral health literacy and a more specific type of functional health literacy that emphasized reading and writing about health. Results showed that 80% of students said that they liked to read, which supported the value of the eBook for Oral Health Literacy© as a vehicle for supporting literacy skills and oral health behaviors in tandem. The eBook narrates the story to children which can help them learn new vocabulary words leading to reading fluency. Fluency is a critical predictor of literacy. By implementing the eBook for Oral Health Literacy© curriculum, students learned to build their functional health literacy which would hopefully promote an ease and liking for reading and increase the amount of time they spend reading to learn facts, topics, and concepts about oral health.

The open-ended questions in this study, prompted students to elaborate on their liking of two chapters in the eBook for Oral Health Literacy© curriculum. For the purposes of this study, liking was conceptualized as a plain language word that helped children to identify their feelings, attitudes, or preferences for something. Often children do not prefer things that are new or foreign to them (e.g., vegetables), which has been coined "neophobia" (Chawner & Hetherington, 2021).

For example, when children say they don't 'like' milk, nutrition educators can talk about and differentiate between dairy and nondairy milk examples and help them to understand that each serving of milk provides 25% of the calcium needed each day (National Dairy Council, 2019). Such information allows educators to examine children's preferences so they can reframe their thinking on why an item they disliked may actually be important, helpful, or healthy for them; ultimately this interactive health literacy process can help children build their functional health knowledge even more. After understanding why some children may not "like" milk, health educators can talk about the benefits of milk to reframe the children's beliefs; this interactive health literacy process of talking and/or reading about milk also increases children's functional health knowledge as long as educators use valid and reliable health information and concepts.

When children were asked the question, "Do you like to read?" (*n* = 18), six children said that they liked to read all the time and eight students said that they sometimes liked to read. These children were able to recall and write about what they liked and learned from the book after a short one-time exposure, as well as being able to recall words and pictures that stood out to them from the eBook for Oral Health Literacy© curriculum. These findings are supported by a study by Zullig et al (2017) who found that oral health behaviors were significantly related to reading behaviors among 7th and 8th graders. If health educators teach about oral health topics earlier in the elementary school curriculum using a meaningful multimodal intervention that is easily recalled (Ubbes et al, 2018c), children will have a stronger foundation for their oral health and overall general health since the two are inextricably linked (National Institute of Dental and Craniofacial Research, 2021).

Functional health literacy is the ability to read, write, and speak about health (Ubbes & Ausherman, 2018). Even if children can read and write at requisite levels for schooling, few children have been exposed to enough health-related topics and concepts to have a strong vocabulary about health. Low vocabulary in health education limits the transition from basic literacy to health literacy. Studies have shown that vocabulary knowledge is requisite to reading comprehension and meaning making (Dong et al., 2021). An important educational goal would be to focus on functional knowledge about nutrition and oral health that includes valid and reliable information from which to function in everyday situations and routines. As such, the process of reading about valid and reliable health information can support children in their development of more background knowledge from which to communicate and act on health information, set goals, and make decisions about health.

Goal 3. To determine whether children brushed their teeth in the morning; had any cavities; had teeth or mouth pain; and visited the dentist in the last year for a dental checkup

Eighteen third grade students answered four multiple choice questions and one open-response question regarding their oral health habits. All but one student replied "Yes" when asked, "Have you been to the dentist in the last year?" Although it is positive that only one student had not "been to the dentist in the last year", everyone is recommended to see a dentist every six months. Twelve students reported that they did not have any cavities. Specifically, four students reported that they had one cavity, one student had two cavities, and one student had eight cavities. Based on the small sample of students, it can be concluded that one in three third grade students had at least one cavity. With oral caries being a completely preventable infectious disease, this statistic is troubling. Despite the high number of students with at least one cavity (n=6), only one student reported missing school because their teeth hurt.

Other results showed that fifteen third grade students brushed their teeth in the morning whereas three students replied "No". Results showed that one in five students (20%) brushed their teeth in the morning. Guidelines suggest that this number can and should be much higher due to the recommendation that children should brush their teeth twice a day with fluoridated toothpaste (Thornton-Evans et al., 2016). Brushing one's teeth is an important habit for students to adopt, which should be added to their daily routine in the morning and at night. Research indicates that there are several barriers that keep children from brushing their teeth (Duijster et al., 2015), including lack of knowledge, poor accessibility to dental products (e.g., toothbrush, toothpaste, and floss), and limited role models. Although dental products are often distributed to children during a dental checkup, not all children have access to dental checkups due to geography, transportation, and/or financial barriers. School-based health clinics may be one of the most important and easily accessible ways that children can be supported with their overall health and oral health hygiene, specifically (Knopf et al, 2016). The placement and use of the eBook for Oral Health Literacy© curriculum in school-based health clinics should be studied in the future.

Limitations

The main limitation of the study was a small sample size (*n* < 50). Future studies will need to be conducted beyond a convenience sampling in order to have more participants and a control group used in the research. The second limitation was that reading or writing were not directly assessed in this study. The acquisition of literacy leads to functional changes in

several cortical structures in the brain, including white matter interconnections that are predictive of reading performance (Lopez-Barrosoet al., 2020; Thiebaut de Schotten et al., 2014). Moreover, the ability to gain access to reading and writing scores of children for health education research is fraught with challenges. Child-centric surveys that measure recognition of oral health words and reading of health-related terminology in different contexts should be developed to address student gains in functional health literacy in oral health, nutrition, and other health behaviors. The third limitation was that we were not privy to classroom conversations that occurred between the dietitian and the elementary children. As such, we only have written answers from students to determine how much learning occurred. Since functional health literacy addresses the ability to "read, write, and speak about health" (Ubbes & Ausherman, 2018; Ubbes et al., 2018b), future research should attempt to transcribe verbal and nonverbal communication of children in the classroom when teaching other multimodal chapters of the curriculum. Understanding how much reading, writing, and speaking occurs in the health education classroom by children may be helpful for establishing instructional parameters for how functional health knowledge contributes to the development of functional health literacy (and vice versa). Investigative studies what assess the synergy between health literacy and functional health literacy may ultimately lead children to make decisions and set goals for their health once they understand the noun and verb vocabularies that inform their actions to do so. As such, noun and verb cues like 'decision' and 'to decide', or 'goal' and 'to set a goal', respectively, become key lexical milestones for that informs the development of functional health literacy.

Conclusion

An eBook for Oral Health Literacy© curriculum was used as a brief intervention to help school-aged children use their functional health literacy skills of reading, writing, and speaking to learn about oral health hygiene and the importance of choosing healthy food and beverages for their teeth. The curriculum focused on building functional knowledge about oral health hygiene and nutrition behaviors through a health literacy intervention that highlighted the need for reasoned actions when setting food goals for healthy teeth and making decisions to keep teeth healthy and strong. The visual-textual-gestural narrative helped children to build a vocabulary about oral health when reading and writing about health. Children wrote about words and phrases that they recalled after reading each chapter. Their elaborations exemplified the importance of using a constructivist theoretical framework to elicit children's functional health knowledge about oral health and nutrition. Chi-square results showed that there was a moderate significant correlation between children who reported brushing their teeth in the morning and having been to the dentist in the past year (p = .021). The use of the eBook for Oral Health Literacy© curriculum can help children to learn functional health knowledge about brushing, flossing, and rinsing teeth, eating nutrient-dense foods and beverages, and going to the dentist for a checkup, including skill-based vocabularies about making decisions and setting goals for health.

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Effects of Balance Training Using Action Songs on Postural Control and Muscle Strength in Preschool Children

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Abstract

Postural control and muscle strength are important factors for the performance of everyday activities and reduce the possibility of fall-related injuries. The purpose of this study was to investigate the efficacy of a balance training program using action songs on balance and strength of preschool children. A total of 51 preschool children were randomly divided into an intervention group (25 children) and a control group (26 children). The intervention group received a balance training program with action songs (six weeks, two times a week, total 12 sessions), while the control group followed the normal curriculum. Prior to and after the intervention, both groups were assessed in dynamic balance (walking on balance beams), static balance (single-leg stance on forceplate and Flamingo test) and strength (long jump and handgrip). The results showed that the intervention group performed significantly better in the dynamic balance and Flamingo test. There were no significant differences in the centre of pressure (CoP) displacement in the Medio-Lateral direction (CoP/ML), the Anterio-Posterior (CoP/AP), and the strength variables. The reliability of the single-leg test on the forceplate was moderate. Moreover, there were no correlations between balance and muscle strength variables. It can be concluded that the balance training program with action songs constitutes an effective activity for developing preschool children's balance, but not strength. Perhaps balance and muscle strength are independent of each other and may have to be trained with complementary activities. Moreover, the results of the study and the behaviour of the children during the one-leg stance test on the forceplate gave rise to questions regarding the appropriateness of this test for preschool children.

Keywords:

Postural Control, Muscular Strength, Physical Education, Preschool Children, Action Songs

Introduction

Balance is fundamental in order to safely perform basic daily movements and sport activities. Moreover, the risk of falls-related injuries is particularly high in young children, because their postural control system is not fully developed (Altınkök, 2015). Recent studies show that balance control develops not only as children grow but also from interacting

with their environment (Chatzopoulos, 2019). If a child does not receive the appropriate stimuli for balance improvement, this may result in limited efficiency in performing fundamental movement skills (Lykesas et al., 2020) and daily activities (Murphy et al., 2003).

Balance control is important for sport performance and past studies investigated the effectiveness of balance training programmes on postural control in healthy trained children, adolescents and adults (Gebel et al., 2018; Wälchli et al., 2018). The common feature of these programs is the inclusion of many repetitions of the same task (e.g. stand still for 20s, 3 times), many sets (3-5), rest periods (e.g. 30-120 s) between repetitions or sets, and competitive games (Abuín-Porras et al., 2020; Gebel et al., 2020; Granacher et al., 2010; Wälchli et al., 2018). Due to their intense training orientation these programs may be effective for athletes or older adults, but they are not attractive to young children. For instance, Granacher et al. (2011) reported that their balance programme was not efficient in improving the balance of elementary school children, and attributed the inefficiency of their programme to the lack of children's interest in participating in highly structured exercises. Their training programme included a 10 min warm-up, 45 min balance activities (4 sets of 20 sec of each exercise with 2 min rest between the exercises) and 5 min cooldown (total duration 60 min). Apparently, it is difficult for children to remain concentrated for so long (one hour) in a training program that involves many repetitions, sets and rests. Highly structured programs may be suitable for adults and athletes; however, they do not meet the needs of young children.

The average concentration span of pre-schoolers is less than 15 min and depends on their interest in the task and the challenges (Mahone & Schneider, 2012). Balance exercises require high levels of concentration and preschool children are overloaded when the duration of assigned structured motor programs is over 30 min (Hastie et al., 2018). Moreover, Kannass et al. (2006), reported that the average duration of young children's participation in the same motor activity is approximately 3 min. Therefore, a balance programme where the duration of each station lasts more than 3 min is difficult to maintain the concentration of young children in high levels.

Action songs combine music and movement and encourage children to move by following the directions in a song or by making movements to dramatize the lyrics. Moreover, action songs offer children the opportunity for personal expression and increase their motivation for participation in physical activities (Chatzihidiroglou et al., 2018; Sumantri et al., 2021). In the pretend play environment of action songs children can make mistakes and try out new challenging activities without the anxiety for performance outcomes. Therefore, an appropriate selection of action songs with balance requirements could be an attractive approach for improving young children's postural control. The first aim of the present study was to investigate the effects of a balance programme using action songs on children's postural control.

The execution of balance activities requires muscle strength, and recent studies reported that balance training (BT) has the potential to improve strength parameters in adults (participants age up to 40 years) (Gruber et al. 2007; Zech et al. 2010) and older adults (60 years and older) (Shim et al. 2018). Regarding youth athletes (10–18-year-old soccer players), Hammami et al. (2016) reported medium correlation between balance (Stork test) and strength (standing long jump) in 16–18-year-old athletes and low correlation in 10-11-year-old athletes. Moreover, Gebel et al. (2020), reported that the correlation between balance and muscle strength in youth athletes is low and it increases with maturity. However, these studies provide only a correlational link between balance level and strength rather than a causal effect that balance training improves strength. For example, the correlation between balance and strength in athletes could be attributed to their training content.

Regarding young elementary non-athlete children (first grades of elementary school), the findings of a few studies investigating the impact of BT on the muscle strength are controversial. Wälchli et al. (2018) and Schedler et al. (2020) reported strength improvements, whereas, Granacher et al. (2011) reported no effects of BT on strength. To our knowledge, no study has investigated the effects of BT on strength performance in preschool children. It is well established that intersegmental coordination is not fully developed in preschool children (4-5 years old) and that they activate more muscle groups for postural adjustments compared to elementary school children (Assaiante et al., 2005). Specifically, preschool children increase the head-trunk stiffness in order to maintain balance control, which suggests an "en bloc" operation of the head-trunk unit. Moreover, preschool children show higher activation levels of hip and knee muscles for balance control compared to elementary school children (Assaiante et al., 2000). Therefore, the hypothesis of the present study was that balance training programmes may be effective in improving muscle strength in preschool children because the level of their muscle activation is higher compared to that of elementary school children and adolescents (Assaiante et al., 2005).

Previous research examining the effects of balance programs on children has used expensive equipment (e.g. air cushions, Bosu) and can hardly be implemented in physical education preschool settings (Wälchli et al.,

2018). Moreover, typical balance training programs for older children and adults include many repetitions of the same exercises and are not appealing to preschool children. On the other hand, preschool children are involved in action songs with great enthusiasm. If a child is having fun and enjoying participation in an activity (e.g. action songs), it is more likely to repeat the balance activities and thereby increase balance control. Therefore, the aim of the present study was to investigate the effects of a BT program using action songs on postural control and muscle strength in preschool children.

Methods

Participants

According to G*Power the minimum required sample size is 34 participants (effect size f = .25, alpha = .05, and power = .80) (Faul et al., 2007). The sample of the current study comprised 51 preschool healthy children (24 boys, 27 girls). The children were recruited from 2 volunteering preschool centre and were randomly assigned to the intervention (25 children, 12 boys and 13 girls), and the control group (26 children, 12 boys and 14 girls). The eligibility criteria were a) the children had no physical condition affecting their participation in Physical Education and b) they had no diagnosed disorder of cognition (assessed by teacher questionnaire). The characteristics of the children are presented in Table 1.

Informed consent was obtained from the guardians of the children, and they could withdraw from the study at any time. The study was conducted in accordance with the ethical guidelines of the local University and all procedures followed the latest version of the declaration of Helsinki.

Procedures

The intervention group followed a 6-week balance training program using action songs (two times a week, total 12 sessions, 30 min/session). Each activity in the action songs (i.e. movement steps and poses of the choreography) had three progression levels (Table 2).

The intensity of the exercises was progressively increased (a) by reducing the base of support, (b) by using dynamic arm/leg movements to perturb the centre of mass, and (c) by using different surfaces (hard surface, soft mat). Progression within the program was done with safety in mind and great attention was given to develop children's understanding of safe practices. In order to increase the motivation of the children they could perform the activities in their own way and instructions were given with analogies (Chatzopoulos et al., 2020).

The tempo of the action songs was 120-130 beats/min, which is close to the preferred tempo of preschool children and the meter simple duple time of 4/4

Table 1.
Characteristics of the children

	Intervention	Control
Age (years)	4.82±.59	4.90±.49
Weight (Kg)	20.03±3.48	20.21±3.04
Height (cm)	109.32±4.29	110.11±4.96

Table 2.
Progressive balance program

Balance exercise	Level 1 Reducing the base of support	Level 2 Displacement of the centre of mass	Level 3 Surface
Two leg Standing balance activities	Double-leg balance, upright stance (variations including wide stance, narrow stance, semitandem, and tandem).	Dynamic arm movements (e.g. rise right hand, rise left hand, rise both hands and down). Forward and backward arms sway, lateral sway (side to side). Body sways (forward/backward, sideways).	Hard surface Soft mat Half foam roll
Single-leg balance activities	On toes, heels.	Dynamic leg movements. Combinations of arm/leg movements.	

(Chatzihidiroglou et al., 2018; Chatzopoulos et al., 2018). The movement patterns included: Step touch, Step knee, Leg curl, Step kick (front, side), Plieu touch, Turn, Toe tap, Heel touch, Lunges (forward, sideways) and heel-toe walk. For example the song "Hokey Pokey": "You put the right foot in (Toe tap front), you put your right foot out (Toe tap back) and shake it all about (one leg standing and shake the other)....". The combinations of the movement patterns were structured in 32 count blocks. The program included the following action songs:

- A Puppet said to Me...
- I'm a Stork.
- Hokey Pokey.
- Do the bear walk (https://www.youtube.com/watch?v=KG3AO6lJ4BQ).
- Balance On One Foot (https://www.youtube.com/watch?v=aQ2Vco_giiE).
- Balancing Song for kids (https://www.youtube.com/watch?v=Vcllldqzt_-w&list=RDVcllldqzt_-w&start_radio=1).
- Hop a little jump (https://www.youtube.com/watch?v=TmXS7Rxx-Xo).

The intervention group was taught by a physical education (PE) teacher with a preschool teacher certification. During the 6-week intervention period, the control group was taught by their teacher and attended the regular PE lessons with fundamental movement skills (locomotor movements and object control with no specific balance exercises) (Kapodistria et al., 2021). All study procedures took place between 10:00–12:00 hr.

Measures

The tests were administered prior to and after the intervention in a quiet room at the preschool center. Every child was tested individually, under the same conditions. The Physical Education post graduate students responsible for administering the tests were blinded to group allocation.

Single leg stance on forceplate

The children performed one practice trial and two 10 sec trials of the one-leg stance on a force platform (KINVENT, www.k-invent.com, sampling rate 75 Hz), with a rest of 30 sec in between. The dependent variables were peak-to-peak amplitude of Center of Pressure (CoP) in the Anterior-Posterior (CoP/AP) and Medial-Lateral (CoP/ML) direction. The mean of the two trials was used for analysis. During the measurement some children could not perceive the point of the task and after a few seconds, they lost their concentration and started to move/laugh or look at the examiner. For this reason, we decided to use a second test for static balance the Flamingo test. The reliability of the test is presented in the results section and is further discussed in

Flamingo test

The children stand on a beam (5 cm high, 3 cm wide), on their preferred leg for 60 sec. Each contact of the free leg with the ground is recorded as a penalty point. The measurement is stopped at 30 points. For data analysis was used the sum of the points. The lower the number of penalty points the better the performance of the child. The reliability of the test is r≥.70 (Bös et al., 2004)

Dynamic Balance

Dynamic balance was assessed using the test "walking on balance beams" (6, 4.5, and 3 cm wide, 3 m long) (Krombholz, 2018). After a practice trial, the children started the test with the 6 cm beam. The number of steps on each beam without losing balance (feet touches the floor) was recorded. The maximum number of steps on each beam is 8, and the maximum score 24 (8 steps x 3 beams). In a pilot study with 18 preschool children the test-retest reliability was very high (r = .75).

Standing long jump

The muscle strength of the lower limbs was assessed using the standing long jump test. The children were instructed from a standing position to jump as far as possible. The best performance of two trials was used for statistical analysis. The test is reliable in 4-6 year old children (test-retest reliability r = .68), (Wick et al., 2021).

Handgrip strength

The handgrip strength test was used for upper-limb muscular strength (acquisition frequency 75 Hz, KINVENT, www.k-invent.com). The children squeezed the dynamometer at maximum effort for 3 sec. The best performance of two trials was used for analysis. The test is reliable in 4-6 year old children (ICC=.91) (Wick et al., 2021).

Statistical analyses

The data was analysed using a mixed ANOVA with the between-subject factor "group" (intervention vs. control), and the within-subject factor "time" (pre vs. post-testing). Homogeneity of variances (Levene) tests were conducted for all dependent variables. In case the assumption of sphericity was violated, the Greenhouse-Geisser correction was used. In the case of significant interaction, follow up t-tests were conducted to identify significant differences. The correlation between the variables and intra-session reliability was assessed using Pearson's r

correlation coefficient. Moreover, effect sizes of ANOVA are presented as partial eta square and for t tests as Cohen's d values. All statistical analyses were conducted using SPSS version 22 (IBM Corporation). Statistical significance was set at $p \leq .05$.

Results

Mean and standard deviation of the variables are presented in Table 3.

Abbreviations: *Significant difference between the two groups ($p < .05$), Dynamic Balance (DB), Centre of Pressure (CoP) displacement in Mediolateral (CoP/ML) and Anterioposterior direction (CoP/AP).

Dynamic Balance

Mixed ANOVA demonstrated a significant interaction effect between group (intervention vs. control) and time of measurement (pre vs. post-testing) ($F_{1,49} = 4.59$, $p = .03$, $\eta p^2 = .08$). At post-testing, follow up t-tests showed that the intervention group improved significantly compared to control ($t = 2.10$, $p = .04$, $d = .59$).

One leg stance on forceplate

Center of Pressure (CoP) in the Medio/Lateral (CoP/ML)

No significant interaction effect was observed between time of measurement and group ($F_{1,49} = 3.79$, $p = .06$, $\eta_p^2 = .07$). Moreover, there were no statistically significant differences between the groups neither at pretesting ($t = 1.32$, $p = .19$, $d = .37$) nor at postintervention measurement ($t = .41$, $p = .68$, $d = .11$). The intra-session reliability was moderate ($r = .53$, $p < .001$).

Center of Pressure (CoP) in the Anterior/Posterior direction (CoP/AP).

There was no statistically significant interaction ($F_{1,49} = 3.26$, $p = .08$, $\eta_p^2 = .06$). Follow up t-tests showed no significant differences between the two groups neither at preintervention ($t = .84$, $p = .40$, $d = .23$) nor at postintervention testing ($t = .77$, $p = .44$, $d = .21$). The intra-session reliability was moderate ($r = .598$, $< .001$).

Flamingo test

Mixed ANOVA showed a significant interaction effect between group and time of measurement ($F_{1,49} = 15.96$, $p = .001$, $\eta_p^2 = .24$). At pretesting, there were no differences between the groups ($t = 1.27$, $p = .20$, $d = .35$). At the post-testing, the intervention group performed significantly better in comparison to control ($t = 2.09$, $p = .04$, $d = .60$). The intra-session reliability was high (Pearson's $r = .702$, $p < .001$).

Standing long jump distance

There was no significant interaction effect ($F_{1,49} = .69$, $p = .69$, $\eta_p^2 = .41$), and follow up t-tests showed no significant group differences neither at pretesting ($t = .94$, $p = .34$, $d = .26$) nor at postintervention testing ($t = .68$, $p = .09$, $d = .47$). The intra-session reliability was high ($r = .917$, $p < .001$).

Hand-grip strength

According to repeated measures ANOVA there was no significant interaction ($F_{1,49} = .02$, $p = .87$, $\eta_p^2 = .001$). Moreover, no significant group differences were observed neither at the beginning ($t = 1.57$, $p = .12$, $d = .44$) nor at postintervention measurement ($t = 1.60$, $p = .11$, $d = .44$). The intra-session reliability was strong ($r = .92$, $p < .001$).

Correlations

Table 4 summarizes the correlations between the variables (Pearson's r). There was no correlation between balance (dynamic or static) and strength (jump or handgrip). Jump and Handgrip showed a moderate correlation ($r = .517$).

Table 3.
Mean and SD of the variables in pre- and post-tests

	Intervention group		Control group	
	Pre	Post	Pre	Post
DB (steps)	11.56 ±8.06	17.56 ±9.52*	10.19 ±6.29	12.26 ±8.36
CoP/ML (mm)	30.16 ±7.47	26.86 ±5.26	27.61 ±6.27	27.47 ±5.21
CoP/AP (mm)	43.89 ±16.06	40.45 ±12.99	41.09 ±13.63	44.62 ±18.31
Flamingo (contacts)	20.36 ±6.64	13.82 ±6.76*	18.30 ±4.67	17.28 ±4.96
Jump (cm)	70.22 ±20.49	73.76 ±18.31	65.38 ±15.82	66.09 ±13.92
Handgrip (Kg)	5.55 ±1.44	5.73 ±1.38	4.95 ±1.25	5.17 ±1.12

Table 4.
Correlation matrix between Dynamic Balance (DB), Flamingo test, Centre of Pressure (CoP) Displacement in the Mediolateral (CoP/ML) and Anterioposterior direction (CoP/AP), jump and grip

	Flamingo	CoP/ML	CoP/AP	Jump	Grip
DB	-.545**	-.377**	-.276*	-.074	.171
Flamingo		.351*	.230	.098	.138
CoP/ML			.798**	.178	.188
CoP/AP				.117	.183
Jump					.517**

Abbreviations: Pearson's correlation *p < .05, **p < .01.

Discussion

The purpose of the present study was to investigate the effects of BT using action songs on the balance and strength of preschool children. Six weeks of BT resulted in improvements in static and dynamic balance in 4- to 6-year-old children but not in strength. Moreover, no correlations were observed between postural control and muscle strength.

Given that no study has been done to examine the impact of BT using action songs on balance and muscle strength in preschool children in a school setting, the findings of the present study have to be compared with those few studies with conventional balance training programs, i.e. with specific balance equipment and competitive activities (Wälchli et al., 2018). Shim et al. (2021), reported that 15-20 minutes of continuous movement of pedal-less bicycle riding (4 weeks duration, 3 times a week), resulted in postural control improvements in preschool children (aged 3-5-years old). The advantage of the present study compared to Shim et al. (2021) is that no particular equipment is required for the balance training program. Moreover, specific balance equipment like bicycles or other unstable training devices (e.g. air cushions, ankle disks) not only are expensive, but also for safety reasons require a ratio of one teacher to one preschool child during the training, which is impossible within a regular preschool physical education setting.

Although past literature seems to agree that BT is effective in promoting postural control in adolescents and adults, there are conflicting results regarding the effects of BT on pre-adolescent children (Granacher et al., 2011; Wälchli et al., 2018). Granacher et al. (2011), reported that 4 weeks (3 times a week) of BT using unstable support surfaces with a predefined number of sets and durations (i.e. typical BT) did not improve balance parameters of elementary school children. The authors attributed the insignificant improvements to the maturational deficits in the postural control system of prepubertal children, and speculated that prepubertal children lacked important neurophysiologic prerequisites for adaptive processes after BT. On the contrary, Wälchli et al. (2018) reported balance improvements in elementary school children after a BT with unstable devices (e.g. Pedalo) and competitive balance games. Similar balance improvements in 10-year-old children were reported by Donath et al. (2013) after slackline training and Muehlbauer et al. (2013) after inline skating (11 years old). It seems that apart from children's maturation stage, the content of the BT may greatly influence the outcome in postural control. Highly structured balance training regimens with many repetitions and rest times are not appealing to young children. Especially preschool children lose their interest in highly structured activities quickly, due to their limited attention span (Oliveira et al., 2019). Therefore, for future studies with preschool children great caution should be given to the attractiveness of the intervention content. Moreover, for future research the investigation of children's interest for balance activities would be particularly enlightening.

In the present study, balance training using action songs had no effect on children's strength. Since this study is the first that examined the effects of balance training on preschool children's muscle strength, the findings are discussed in relation to studies with cohorts of older children. A few recent studies on older children (8-12 years) showed that balance training with specific devices generated significant increases in strength (Wälchli et al., 2018). Kocjan et al. (2020) reported that unicycling riding proved to be an effective tool to develop strength in 12-year-old children (six weeks, 12 sessions, 2 training sessions per week, 45 min per-session). In addition, Muehlbauer et al. (2013) demonstrated significant strength improvements (jump height) after a 4-week inline skating program (2 times/week, 90 min. each). The divergent findings of these studies compared to our study could be attributed to the different training content of the studies. Learning to ride a unicycle (or inline skating) and jumping with it around the marks requires much more strength resources than standing on one leg and moving arms/legs as in the present study. Apparently, different balance exercises have different effects on strength. Another reason for the insignificant strength results in the present study could be the maturation stage of the cohort in combination with the duration of the intervention. It is well established that inter- and intramuscular coordination (i.e. neural parameters, that are decisive for strength improvements), is not fully developed in preschool children (Assaiante et al. 2005). Moreover, Wick et al. (2021) demonstrated muscle strength improvement (in standing long jump performance) in preschool children after 30 sessions of a strength-dominated exercise program involving countermovement jumps, lunges, single leg jumps, plank and table position. Similar improvements in muscle strength in preschool

children were reported by Andrieieva et al. (2021) after a fitness program in a sport club that lasted 9 months. Perhaps due to the low maturation stage of preschool children, a longer intervention duration than the 12 sessions applied in the present study, is needed for strength improvements. Further research is necessary to elucidate the strength issue after balance training in terms of exercise content and intervention duration.

According to the results of the present study there were no correlations between strength and balance variables. To the authors' knowledge there are no other studies available that investigated the relation between balance and muscle strength variables in preschool children. Thus, the findings are discussed in relation to studies with older age groups. In contrast to our results Gafner et al. (2018) reported associations between muscle strength (hip muscle and hand-grip strength) and postural control in older participants (>65 years old). Moreover, Jeon et al. (2022) demonstrated that the muscle strength of knee extensors was positively related to the star excursion balance test (SEBT) in young adults. The controversy results between the aforementioned studies and the present study could be attributed to the different measurements applied in the studies. In the study of Jeon et al. (2022) was applied the SEBT, whereas in the present study the one-legged stance test. In the SEBT the participant is required to maintain standing with one leg while maximally reaching in several directions with the other leg. The more one participant has strong lower limb muscles and can flex the hip and knee of the standing leg the longer he/she can reach with the opposite leg. Therefore, the muscle strength of the stance-leg is important for maximum reaching distance in the SEBT and it is plausible to find correlations between muscle strength and SEBT (Filipa et al., 2010).

The lack of correlation between muscle strength and balance variables of the present study are consistent with the results of Granacher et al. (2011), who reported no association between one-legged stance and countermovement jump in adolescents participants. Moreover, McCurdy et al. (2006) demonstrated no relationship between one-legged stork stand and squat strength in young adult participants (mean age 22 ± 2 years). Our data agree with those of Granacher et al. (2011) and McCurdy et al. (2006) and extend their findings by adding an additional age group (preschool children) to the existing knowledge on adolescents and adults. Based on these results it can be argued that muscle strength and postural control are independent factors that may have to be trained with specific activities. This speculation could be reinforced by the results of Andrieieva et al (2021), who reported balance and muscle strength improvements in preschool children after a fitness program of nine months.

The single-leg stance test on the forceplate is one of the most frequently used tests in the literature for postural control evaluation (Zumbrunn et al., 2011). However, we observed that this task was not appealing to young children. They could not comprehend the point of the task, and after a few seconds they lost their concentration and started to play (e.g. hopping, looking at the evaluator, laughing). The medium reliability of CoP/ML and CoP/AM (r = .530 and r = .598 respectively) could be attributed to the children's lack of interest in performing the task. On the other hand, the reliability coefficient in the flamingo test was very high (r = .702). Based on our experience, our impression is that the flamingo test was much more interesting than the single-leg stance test. Therefore, for future studies with young children, we suggest the implementation of attractive tests where children can evaluate their own performance.

Limitation

A limitation of the present study relates to the concentration of young children during the measurements. Although the tests were conducted in a quiet room and were presented like games, we cannot be sure about the level of children's concentration and that they really gave their best.

Conclusion

The results of the present study demonstrated that a short-term balance training program (12 lessons) using action songs produces significant balance improvements in preschool children. However, it seems that this short period is not sufficient to induce significant muscle strength improvements. Moreover, there were no correlations between balance and muscle strength variables in preschool children. This finding could be an indication that these variables are independent of each other and maybe they should be trained with complementary activities in preschool children. Based on the findings, the implementation of action songs with balance requirements in the regular preschool curriculum is a safe and feasible training modality for the improvement of postural control of young children.

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