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A research proposal for mathematics education: Innovative design thinking using eye tracking technology

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Abstract

Understanding the experience and revealing the perception of users towards the products takes the attraction of many researchers, which increases the popularity of the "design thinking" for different research disciplines. In order to serve the product to satisfy needs of target users more efficiently and improve the product and user interaction, the design of the product by means of research field, content, process, methodology has also gained importance in mathematics education. In this study, comprehensive literature research on the role of design in mathematics education and use of eye tracking technology is given in detail. It is suggested to create alternative design categories for a special user group as mathematically gifted students while achieving mathematical tasks related to the fraction concept. Five different models of mathematical tasks expressed as written symbols, manipulative models, oral language, picture and real-world situations were designed for mathematically gifted students whose differentiated characteristics and needs require to be searched. Since proposing effective and differentiated content compatible with their needs is crucial, their reactions through gaze behaviors towards different contents were proposed to be recorded with the use of eye tracking technology, which generates quantitative data. In addition to benefiting from the advantageous position of eye tracking technology in providing methodological efficiency for instructional design studies, the data regarding personal evaluations of the students as qualitative judgments were also suggested to be obtained from the participants simultaneously. This proposal highlights the importance of systematical understanding and revealing the hidden interests of gifted students. It also has a potential to provide an initial guide for both design and mathematics education researchers concerning how an optimum mathematical task should be designed and how eye tracking technology can generate a roadmap in the instructional process.

Keywords: Eye Tracking Technology, Gifted Students, Mathematics Education, Product Design Decisions

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Product design manifests itself in multiple forms and contexts, shaping how individuals interact with both tangible and intangible systems. Judgments of product preference frequently underscore the salience of visual elements in shaping user perceptions. While design may refer to the perceptible characteristics of a physical artifact, it also encompasses the experiential qualities of digital products and even abstract processes (Jiang et al., 2007; Lobach, 1976; Tunali, 2009). In contemporary educational contexts, it has become increasingly important to integrate design principles into curriculum development—ensuring coherence, consistency, and scope—so as to enhance learning experiences (Darling-Hammond & Hammerness, 2005).

Within this study, we aim to leverage the potential of design to make meaningful contributions to mathematics education, particularly for specialized learner populations such as mathematically gifted students. Existing instructional methodologies remain limited in their capacity to fully support the cognitive potential of mathematically gifted learners, thereby constraining their opportunities for advanced conceptual development (Leikin, 2021). Traditional pedagogical approaches often fail to accommodate these students' distinctive cognitive profiles, which demand intellectually rigorous and open-ended problem-solving opportunities (Assouline et al., 2013).

Eye-tracking technology offers a promising, yet underexplored, avenue for objectively examining indicators of cognitive engagement—including attention allocation, information processing patterns, and problem-solving strategies (Holmqvist et al., 2011). By capturing and analyzing students' visual behavior, eye-tracking data can inform the design of instructional interventions tailored to the learning needs of mathematically gifted individuals. In particular, this technology can provide insight into students' strategies during cognitively demanding mathematical tasks, thereby enabling the development of pedagogical approaches that foster deeper learning and advanced problem-solving (Halszka et al., 2017). Addressing this methodological gap by systematically incorporating eye-tracking into mathematics education research represents a critical step toward enabling individualized learning pathways and gaining a richer understanding of students' affective and cognitive engagement.

Building on this rationale, the present study proposes a systematic analysis of the literature connecting product design, mathematics education, gifted education, and eye-tracking research. Based on this review, we propose a structured framework for content design and a methodological approach for evaluating alternative design solutions. Central to this framework is the premise that mathematical tasks should be conceptualized "through the eyes" of mathematically gifted students. Task design should be aligned both with curricular competencies and with students' intrinsic interests. The study therefore investigates the contribution of eye-tracking technology to mathematics education by analyzing students' interactions with alternative visual task representations.

The scope of the study, summarized in Figure 1, highlights three interrelated foci: (1) the influence of product design principles on mathematics education, (2) the implications of design decisions for supporting mathematically gifted learners, and (3) the potential of eye-tracking technology to inform and optimize instructional design.

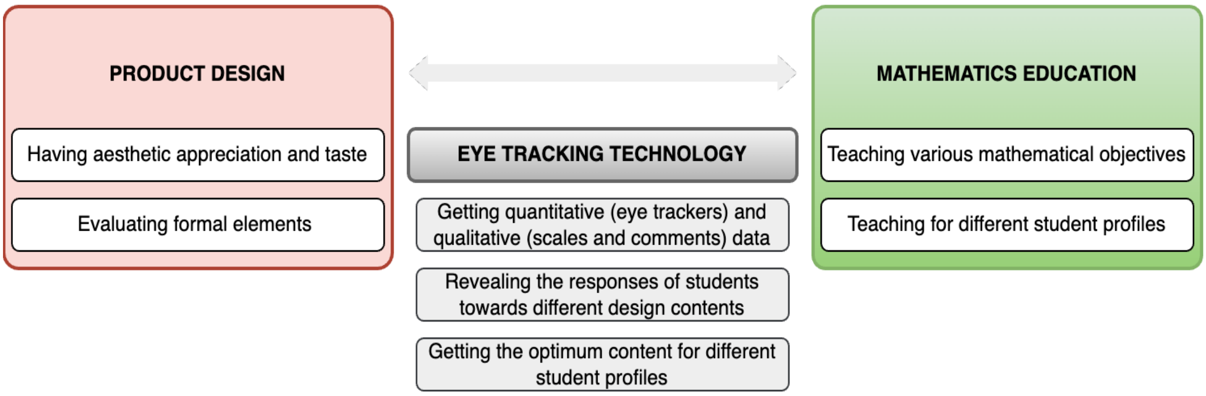

Figure 1. The scope of the study

This research proposal aims to reach the implicit knowledge of interest hidden in the user (a mathematically gifted student solving a mathematical task) through the user. To achieve this main aim, the following goals of the study are determined:

1. To contribute to studies of designers that create educational content with generalizable product decisions in line with visual data analysis,
2. To reveal the usability and methods of eye tracking technology concerning design in mathematics and gifted education.

Based on the goals of this study, the following research questions will be answered:

1. Do the mathematically gifted students doing math produce generalizable information through their eyes from the perspectives of educators and content designers?
2. What are the results of tracking the students' eyes on the products shown on the screen?
   a. Which design elements take the students' attention at the first moment?
   b. Which design elements do the students visit more frequently?
   c. Which design elements do the students spend a longer time?

Within the scope of the study, research related to product design, eye tracking technology and contextualizing this technology from the design and education perspective, characteristics and tasks for mathematically gifted students is conducted and presented below.

Product Design: As an Object of Use

In any interaction between a user and an object, the first impression plays a decisive role. Every object possesses an appearance that evokes an initial affective response—commonly referred to as interest. Lobach (1976) defines industrial products as appearances constructed through formal elements—such as shape, color, material, and surface—that are perceptible to human senses. A well-designed product should address users' sensory–psychological expectations, eliciting a positive evaluative response. In educational contexts, this principle may help explain students' affective engagement with instructional materials. Consequently, it is essential to draw upon theoretical frameworks that conceptualize interest as an emergent property of stimuli, personality, and contextual factors. Jacobsen (2006) developed a multidimensional model in which interest can be analyzed from diachronic (time-evolving), synchronic (simultaneous), cognitive, embodied, content-related, human, and situational perspectives. This perspective acknowledges that human interest may change gradually, as in trends or fashions, or emerge instantaneously through direct comparison among stimuli.

Since the nineteenth century, the growth of industrial production has intensified interest in the aesthetic dimension of products, positioning beauty and attractiveness as value-added qualities alongside functionality (Tunalı, 2009). Product selection increasingly reflects both appearance and functional attributes, thereby foregrounding concepts such as beauty, enjoyment, and appreciation. The key design challenge lies in uncovering users' latent interests. Shelley (2017) argues that beautiful and interesting objects play a central role in perception, which can be understood as the comprehension of a whole. Examining a product's perceptual model thus requires consideration of its physical existence, content, individuality, and usage context, as well as empathic, informational, and meta-level interpretations (Tunalı, 1998). Users construct meaning by integrating products into their perceptual world. The aesthetic attitude focuses on sensations, emotions, empathy, and aesthetic pleasure. Lipps (1906) defined empathy as the establishment of a subject–object relationship; when successful, this relationship allows users to experience pleasure and integrate the product into their bodily and cognitive schema—for instance, treating a mobile phone or vehicle as an extension of themselves. When such empathic relationships emerge, users form value judgments and interpret the product as beautiful. Bense (1969) and Lobach (1976) emphasized that designers attempt to communicate with users through products, to decode the meaning embedded in objects, and to iteratively solve design problems to generate improved solutions.

Psychological research has highlighted the importance of understanding subjective evaluations and judgments regarding product attractiveness. Leder et al. (2004) proposed a model of aesthetic information processing consisting of five stages: perception, implicit classification, explicit classification, cognitive mastery, and evaluation. This model highlights the pivotal role of visual elements in aesthetic experience. Because product evaluations often occur within very brief time intervals, aesthetic judgments tend to be rapid and guided by perceptual heuristics. Gestalt principles—including contrast, complexity, color, symmetry, grouping, and order—play a key role in shaping these judgments (Leder et al., 2004). Empirical evidence supports the claim that these principles underlie aesthetic preference (Arnheim, 1974; Locher et al., 2010). Arnheim (1974) and Kim (2006) identify seven key design principles—balance, emphasis, rhythm, pattern, proportion, harmony, and variety—through which a well-designed product is perceived holistically before attention shifts to individual elements. Similarly, the use of unity, rhythm, the golden ratio, and repetitive visual motifs has been shown to enhance perceptual pleasure (Papanek, 1984). Throughout history, designers have made critical decisions concerning form and visual integrity to create products with universal appeal (Coates, 2003). These decisions typically involve considerations of shape, size, proportion, material, color, decoration, and texture, as well as the interaction and balance among these elements (Kellaris & Kent, 1993).

The relationship between users' cognitive and emotional reactions and their value perceptions of formal innovations has been widely studied. Nikolov (2017) found that individuals tend to prefer attractive designs that provide aesthetic pleasure and satisfy sensory and emotional needs, even over purely functional alternatives. Rindova and Petkova (2007) argued that because formal product features shape users' expectations, attractive products are often perceived as easier to use and more valuable. Similarly, Kotler and Rath (1984) reported that, when comparing two functionally equivalent products, individuals prefer the more aesthetically appealing option. Additional research has emphasized the importance of simplicity, distinctiveness, color, and craftsmanship for effective human–computer interaction and visual aesthetics (Moshagen & Thielsch, 2010). Palmer et al. (2013) further demonstrated that design features such as regular horizontal–vertical alignments, symmetry, curved contours, and adherence to categorical prototypes are generally preferred.

Studies also underscore the emotional impact of formal features. Desmet (2008) demonstrated that visual product characteristics trigger self-focused, activity-oriented, and product-oriented emotional responses. Desmet (2010) reported that design-related visual elements evoke positive emotions and excitement, while later work (Desmet, 2012) highlighted that emotions arising from object meaning, user characteristics, and user–product interactions are all influenced by design. Desmet et al. (2001) further suggested that all products can be analyzed from a visual perspective and that designs with emotional resonance are more likely to attract user interest. Therefore, to understand emotional responses and subjective product evaluations, it is essential to investigate users' visual focus. In design practice, using eye-tracking data to capture users' visual attention provides an empirical basis for revealing interest patterns and can inform the creation of aesthetically and pedagogically optimized instructional materials. Such data may ultimately contribute to establishing a scientific and technical foundation for high-quality educational content design.

Revealing Perception Towards Products: Eye Tracking Technology

The eyes are metaphorical windows of the people that connect the outer world to the inner world and give information about how people see the world. According to Guiping et al. (2011), people perceive more than 90% of the information coming from the outside world with their eyes, which gives visual perception an important place among the other five senses in the human body and makes the vision one of the most important factors affecting psychological activities. Psychologists think that eye movements directly reflect cognitive activities such as gazing, noticing, hoping, memorizing, reading, and understanding. On the other hand, Guan (2007) argued that pupil movements are erased from short-term memory. The places where people actually look at are either forgotten or not mentioned by the viewer with a rate of 47%. In addition, people may forget the object they see, not care about telling it, or may not think that they are looking at it (Albert & Tedesco, 2010). Hence, many studies have emphasized that recording and analyzing gaze by using eye tracking technology can provide objective and supportive data, and objective measurement beyond personal and one-sided thinking of visual attention is a future need (Guo et al., 2019; Hammer & ve Lengyel, 1991; Nayak & Karmakar, 2019; Wang et al, 2020).

The eye has two types of movement. One is fixation, and the other is a short and fast movement (saccadic). Capturing the continuous and rapid movements between eye fixations on a certain area is the focus of eye viewers (Bergstrom & Schall, 2014). That is, fixation and saccades are sub-dimensions typically studied in eye tracking research (Salvucci & Goldber, 2000). Fixation is the moment when the eye remains relatively still and is consciously or unconsciously focused on a specific point or a small area. It can last from a few milliseconds to seconds and is one of the most important eye movements used when collecting data about the participant (Holmqvist et al., 2011). On the other hand, the eyes make rapid ballistic movements called saccades to switch from one fixation to the next (Škrabánková et al., 2019); that is, saccades are rapid eye movements between fixations. Humans make, on average, about three such saccades per second, either intentionally or triggered by a reflex (Jang et al., 2014).

The working principle of eye trackers is based on recording these instantaneous eye positions of the users. There is a layer on the eye that reflects infrared light, and most eye trackers use this effect to enable these recordings. Reflections of an infrared light source from the front on the cornea and pupil make the eye noticeable. With advanced image processing algorithms, the places where each eye looks are recorded by a high-resolution camera (Bergstrom & Schall, 2014; Naschitzki, 2012). There are three different eye trackers on the market, which are standalone, monitor-based, and head-mounted eye trackers. Standalone eye trackers can be set up in a variety of ways, allowing users to engage in interactive work in their own environment. Monitor-based eye trackers allow users to perform on-screen images, videos, web, software, and more detailed studies in a specific location like a laboratory. On the other hand, head-mounted eye trackers as glasses record eye fixation and movements in a full-motion environment such as sports events, grocery shopping, driving, wayfinding, computer games and children's games (Consort World research, 2013).

By means of this advanced technology method, which can be applied in several research disciplines, it is possible to observe the movements of the eye, monitor eye fixation, the sequence of movements and determine the measurable quantities of the gaze (Škrabánková & Trnová, 2015). It is also possible to detect the locations that attract the individual’s attention on the screen and to record eye movements to get information about cognitive processes (Škrabánková et al., 2019). According to Oscar Werner, a managing director of eye tracking company TobiiTech, eye tracking sensors provide two key benefits. The first one is recognizing what the user is interested in at the given time and product, while the second one is allowing the user to engage more with the content, having a smarter user-product experience, without being distracted. Werner suggests that after touchscreen, mouse, keyboard and voice control, eye trackers would be the fifth addition to personal computers and would replace all other devices that can be controlled just by looking (Dickson, 2017). One of the main advantages of this technology, which can be used in a wide range of academic fields including cognitive psychology, educational sciences, virtual reality, computer games, medicine, advertising, marketing, human-computer interaction and user experience design, is enabling the researcher to reveal the significant points even the participants cannot define (Bergstrom & Schall, 2014).

While an eye tracker reveals the way participant views the content and presents these outputs by means of maps), it also offers features such as metric calculation per task, benchmarking, and AB testing. An example of the various outputs as maps that can be obtained with eye tracking technology can be seen in Figure 2. These maps can create useful and easily assessable visuals and a narration about the approach of the users towards the product. The first image is the fixation map, which shows the opposite of what is called a heat map or attention map. This map shows only the places that had been looked or seen by the users, leaving other places in the dark. The second image, in contrast to the first image, shows the heatmap revealing the regions that were viewed more or less intensely. In the third image, the sequence of movement of the eye and the length of the gaze are shown by means of a view path map. The gaze of the eye is numbered starting from one until the last view, and a path is drawn up. In the last image, the regions of interest are demonstrated in the zoning map. Eye movements were evaluated and analyzed according to certain classifications such as title, introduction, and conclusion (Tobiipro.com, 2023).

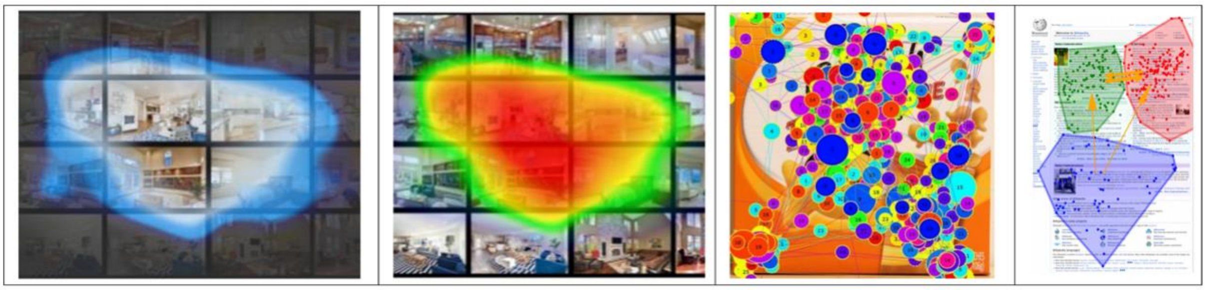

Figure 2. Various eye movement maps (Tobiipro.com, 2023)

In addition to recording eye movements and providing various maps as indicated above, eye trackers also have important functions such as detecting and revealing pupil size. There are two types of muscles in the iris layer of the eye. One of them shrinks the pupil up to 2 millimeters in diameter, while the other dilates the pupil up to 8 millimeters in diameter. It constantly balances pupil size against light and emotional responses. Many psychological factors, including insomnia, introversion, prejudice, autism, and depression can change pupil size (Fong, 2012).

Daniel Kahneman is a Nobel Prize-winning psychologist who has done many studies on pupil size. He analyzed pupil diameter and measured how much memory was loaded with this information for short-term memory tasks (Kahneman & Beatty, 1966). When people make a mental effort to think about something or solve a math problem, their pupils dilate. As soon as the thinking process is completed, the pupils of the eyes become smaller than before. In a verbal learning task, pupils shrink when people remember the answer or repeat the same task. In addition, when the act of thinking occurs without forcing the mind, the pupil size remains the same (Hess & Polt, 1964; Kahneman & Beatty, 1966). When people are under stress, their pupils dilate; while in a relaxed position, their pupils shrink. Pupil size gives away the decisions of people about a particular issue. Neurophysicist Wolfgang Einhauser exemplified this situation in a study. When people were asked to press a button at any time for a period of 10 seconds, their pupils began to dilate in about one second before pressing and reached their maximum level in two seconds after pressing. Thus, it was possible to determine the decisions to be made by the users with the size of the pupil in advance (Fong, 2012). In short-term memory tasks, participants' pupils dilate as they learn about the study and shrink when interpreting the study. The length of the informative sequence given to the user and the difficulty of the task determines the rate of pupil dilation. Peak increase and growth rate of pupil size are higher in long-term memory than in short-term memory. Pupillary constriction shows similar behavior in both memory types (Beatty & Kahneman, 1966). Kahneman et al. (1967) measured the response of eyes to different mental tasks, giving users eight seconds to analyze perceptual deficits. Similar times have passed for observing errors to see how the pupils have changed. Enlarged pupils were found as an indicator of mental effort in activities such as problem solving and describing, recovering from short-term memory, remembering familiar phone numbers, and distinguishing between two tones. In these tasks, the pupil diameter changed rapidly (approximately 1 second after the task was shown). While people were receiving and processing information, first the heart rate increased, then the pupil diameter and then the skin resistance changed depending on the task difficulty (Kahneman et al., 1969). According to Hess and Polt (1960), pupil diameter is an indicator of attention and concern. Describing the mental state in a sensitive and useful way, the pupils dilate in pleasure and shrink in discontent. The prominent titles of these studies on pupil dilation and shrinkage, depending on the action performed or the current situation, are summarized in Figure 3.

Pupil Dilation	Pupil Constriction
With a mental effort	When thinking process is completed
When under stress	In comfortable position
When learning about the work	When interpreting the work
In the moment of pleasure	In the moment of discontent

Figure 3. Factors affecting pupil size

According to the existing studies, while users are investigating a product, the viewing patterns, durations and physical shape of the pupil can give a clue to the researchers regarding the relationship between the users and the products. Therefore, this study tries to reveal the perceptional and sensorial response of gifted students as users while they are having mathematical education through designed instructional content.

Eye Tracking Technology: From Design and Education Perspective

Eye-tracking technology has been increasingly applied in educational research to investigate students' visual behavior in learning environments (Scheiter & Van Gog, 2009). The theoretical foundation of this study is the Eye–Mind Hypothesis proposed by Just and Carpenter (1976), which posits that an individual's cognitive focus corresponds to the object of fixation. Accordingly, eye movements are closely aligned with cognitive processes such as perception, reasoning, and comprehension (Jang et al., 2014; Schindler & Lilienthal, 2017). Recording and analyzing fixation order, duration, and scan paths therefore provide a valuable window into learners' cognitive processes (Škrabánková et al., 2019), enabling researchers to infer complex reasoning patterns that are otherwise inaccessible (Schindler & Lilienthal, 2020).

The growing number of studies employing eye tracking in educational contexts underscores its relevance. Sağlam and Yılmaz (2021), for instance, analyzed trends in educational eye-tracking research in the Web of Science database and reported a marked increase in studies between 2015 and 2019. Their review revealed that Tobii, Eyelink, and SMI are among the most frequently used devices, often complemented by additional instruments such as questionnaires, observation forms, and usability tests. Eye-tracking technology has also been employed to support students with disabilities and children with learning difficulties, guiding the development of instructional adaptations (Garand et al., 2009). By visualizing learners' attentional focus, eye-tracking research provides educators with actionable insights for improving instructional design and enhancing student engagement.

Several empirical studies demonstrate the methodological richness of eye tracking. Khedler et al. (2018) examined the visual behavior and performance of 15 medical students using a serious game, Amnesia, defining task-based areas of interest (AOIs) to analyze performance. Static metrics such as fixation duration and time-to-first-fixation were complemented by dynamic measures such as scan-path analysis. Heatmaps and gaze-path visualizations further elucidated participants' problem-solving strategies. Similarly, Appelt (2016) investigated the usability of an internet safety information guide for elderly individuals, using Tobii software to collect gaze data from 20 participants. Results indicated that older users exhibited longer fixation durations and experienced difficulty with small text, low-contrast displays, and interface navigation, suggesting that poor design elements can hinder information processing and user control.

Eye-tracking research has also gained prominence in mathematics education (Andrá et al., 2015; Epelboim & Suppes, 2001; Schindler & Lilienthal, 2017, 2019). Most of these studies adopt the Eye–Mind Hypothesis as a guiding framework, linking eye movements to underlying cognitive activity (Obersteiner & Tumpek, 2016; Schindler & Lilienthal, 2019). The literature indicates that eye tracking has been effectively employed to explore mathematical creativity (Muldner & Burleston, 2015; Schindler et al., 2016), students' attentional focus during problem-solving (Obersteiner & Tumpek, 2016), and spatially intensive tasks such as geometry, where visual information plays a central role in reasoning (Epelboim & Suppes, 2001; Schindler & Lilienthal, 2019). Additional studies have investigated university students' reasoning about fractions and equivalence (Obersteiner & Tumpek, 2016), function representations (Andrá et al., 2015), and proportional reasoning (Abrahamson & Bakker, 2016). Research has also addressed the usability of mathematics teaching software for secondary students (Tonbuloğlu, 2010) and examined preservice teachers' problem-solving strategies while using dynamic geometry software (Türkoğlu, 2014). While the Eye–Mind Hypothesis provides a strong theoretical basis, scholars have emphasized the need to triangulate eye-tracking data with complementary methods such as retrospective interviews to strengthen interpretive validity (Holmqvist et al., 2011; Schindler & Lilienthal, 2019).

Beyond mathematics education, eye tracking is emerging as a valuable tool in research on gifted learners—a domain that remains relatively underexplored. Eye-tracking studies have shown promise in revealing the problem-solving processes of gifted students and informing the design of instructional materials, including visual and textual elements tailored to their needs (Škrabánková & Trnová, 2015;

Škrabánková et al., 2019). For example, Byeon et al. (2017) examined the attention patterns of science-gifted and non-gifted students during a classification task and found that gifted students predominantly employed inductive reasoning strategies, whereas non-gifted peers relied more on deductive reasoning. Similarly, Škrabánková and Trnová (2015) observed that gifted students were better able to sustain focus and solve cognitively demanding tasks requiring extended concentration. Muldner and Burleston (2015) reported that participants with lower creativity exhibited shorter saccadic path lengths, suggesting less exploratory visual processing. Choi et al. (2012) compared gifted and non-gifted primary school students and concluded that gifted students minimized unnecessary cognitive load by efficiently attending to relevant information.

A particularly notable study by Sajka and Rosiek (2015) compared the eye movements of 52 mathematically gifted and non-gifted students. While no significant difference was observed in total problem-solving time, fixation patterns provided crucial insights into students' problem-solving approaches. Gifted students exhibited a concentrated gaze distribution, focusing primarily on problem-relevant text and optimizing their fixations to support solution strategies, whereas non-gifted students' gaze patterns were more scattered, including irrelevant screen regions. Importantly, the authors concluded that eye-tracking data provided a more objective and reliable measure of problem-solving behavior than participants' self-reported accounts.

Together, these findings underscore the potential of eye-tracking technology to advance mathematics education research, particularly for specialized populations such as mathematically gifted learners. By revealing attentional and cognitive processes with high temporal resolution, eye tracking offers a powerful means of designing adaptive instructional interventions and deepening our understanding of how students engage with mathematical tasks.

Users of the Proposed Design: Mathematically Gifted Students

Gifted students are defined by the National Association for Gifted Children (2005, p. 4) as individuals who "perform or have the potential to perform at an extraordinary level in one or more areas of expression." These students can be classified according to the domains in which they exhibit high potential (Winner, 2000). Among these domains, mathematical giftedness has received considerable attention in both national and international research as a field-specific talent. Mathematically gifted students have been conceptualized as a distinct group warranting specialized study and educational intervention (Leikowski & Lev, 2007; Lupkowski-Shoplik, Benbow, Assouline, & Brody, 2003; Singer et al., 2016).

One of the foundational contributions to this field was made by Krutetskii (1976), who characterized mathematically gifted students as those who "see the world with a mathematical eye." According to Krutetskii, characteristics such as logical reasoning, generalization, creative and flexible thinking, high-level mathematical perception, and advanced spatial ability serve as key indicators of mathematical giftedness. Building on Krutetskii's conceptualization, subsequent researchers have elaborated on these traits. For example, Winteridge (1989) emphasized that mathematically gifted students detect relationships rapidly, grasp mathematical representations intuitively, and easily develop symbolic systems. Greenes (1981), Renzulli (2011), and Sriraman (2005) further highlighted motivational characteristics—including perseverance, commitment to task, and persistence in problem-solving—that distinguish mathematically gifted learners. Additional attributes such as the ability to connect mathematics with real-life situations, generate multiple solutions at an unusually rapid pace, and approach problems creatively are also regarded as distinguishing features of this population (Fıçıcı & Siegle, 2008; Johnson, 2000; Sriraman et al., 2013).

Given these distinctive cognitive and motivational characteristics, mathematically gifted students are considered a special-needs group requiring differentiated or enriched instruction (Akkaş & Tortop, 2015; Baykoç et al., 2014; Klimecká, 2023; Ministry of National Education, 2013; Ngiamsunthorn, 2020). The National Council of Teachers of Mathematics (1991) explicitly described gifted students as among the most underserved learners in terms of realizing their full potential. From the perspective of educational equity (Van de Walle et al., 2019), it is therefore essential to provide learning opportunities that are tailored to their advanced abilities. Researchers have emphasized that mathematical giftedness is often an innate ability or potential—sometimes referred to as a "gift"—that must be nurtured through appropriate learning environments and challenging instructional materials in order to develop into realized talent (Borovik & Gardiner, 2006; Gagné, 2005). Consequently, well-structured and systematically designed educational content is crucial to addressing this global challenge and fostering the optimal development of mathematically gifted students (Baykoç et al., 2014; Diezmann & Watters, 2001; Johnson, 2000; Özdemir & Işıksal-Bostan, 2021; Sriraman, 2003).

Design Materials: Tasks for Mathematically Gifted Students

Societies composed of individuals who can effectively learn and apply mathematics in their daily lives are better positioned to shape their futures. Consequently, taking deliberate steps to support mathematically gifted students—those with advanced knowledge, interests, and skills in mathematics—is of particular importance (Berg & McDonald, 2018). Mathematical tasks, which constitute the core of mathematics teaching (Chapman, 2013), play a critical role in enabling students to construct meaning from mathematical concepts (National Council of Teachers of Mathematics [NCTM], 1991). For this reason, mathematical tasks should serve as a primary point of intervention when seeking innovation, progress, or reform in mathematics education (Arbaugh & Brown, 2005). Accordingly, it is essential to offer students "mathematical tasks that are valuable and worth the effort" (NCTM, 2000, p. 25).

Despite their strong motivation and enthusiasm for learning, mathematically gifted students often report boredom and dissatisfaction with the mathematical tasks presented in classrooms, noting that these tasks lack sufficient challenge and intellectual appeal (Aygün, 2010; Feuchter & Preckel, 2022; Johnson, 2000; Özdemir & Işıksal-Bostan, 2021). In many mixed-ability classrooms, these students receive identical lesson content and at the same pace as their peers, with little or no modification to accommodate their advanced capabilities (Diezmann & Watters, 2001; Dimitriadis, 2011; Johnson, 2000; Mofield, 2020). As a result, there is a pressing need for systematically designed mathematical content that aligns with the cognitive and affective characteristics of mathematically gifted students (Adams & Pierce, 2021; Gavin et al., 2021; Johnson, 2000; Trna, 2014).

Nevertheless, the literature reveals a gap in studies proposing models that guide mathematical task design from the perspective of mathematically gifted learners and within the context of visual design principles that capture their attention. Some research has highlighted the potential of integrating entertainment and interest elements as design considerations in user-centered educational content (Ilhan et al., 2022). Given that mathematically gifted students frequently express challenges such as boredom, lack of engagement, and insufficiently stimulating learning environments, it is necessary to design educational content that incorporates principles of instructional design and leverages the affordances of eye-tracking technology (Schindler & Lilienthal, 2020). The mathematics education research community similarly calls for exploring new opportunities for enhancing learning through innovative tools and design-based approaches (Sinclair & Bruce, 2015).

Building on this need, the present study aims to design mathematically rich tasks and propose a research framework for examining how visually enhanced educational content can be presented to mathematically gifted students. This will be accomplished through the use of eye-tracking technology, allowing for the systematic analysis of students' visual attention, engagement, and cognitive processes during mathematical task-solving.

METHODS

In this research proposal, a recommendation for the comparative examination of the designed mathematical content by means of eye tracking technology over a specific user profile was provided. In detail, an analysis of the gaze movements of mathematically gifted students and their reactions while solving mathematical tasks enriched by different design contents was recommended. This section recommends the methodological framework of design decisions given for the mathematical tasks, study procedure focusing on data collection strategies and proposed empirical experiment.

Design of Mathematical Tasks

In this research proposal, mathematical tasks arranged in line with the design decisions for mathematically gifted students were presented and the investigation of the students' eye movements while they are examining the tasks were suggested. Thus, initially the mathematical tasks were designed. It was proposed to follow the examining process of mathematically gifted students while engaging with these different mathematical tasks related to the sub-learning domain of fractions. The objectives which were used as the framework for the tasks including two fractions with equal denominators or a multiple of one denominator of the other are provided below:

1. The students add two fractions and make sense of this operation.
2. The students subtract two fractions and make sense of this operation.
3. The students solve and set up problems requiring addition.
4. The students solve and set up problems requiring subtraction.

Based on these objectives for mathematical tasks, design decisions were taken related to four main categories which are stated below:

1. Category A: Adding two fractions with the same denominator
2. Category B: Subtracting two fractions with the same denominator
3. Category C: Adding two fractions with different denominators
4. Category D: Subtracting two fractions with different denominators

In addition, while presenting mathematical information to students, it is critical to make use of multiple representations, such as verbal expressions, pictures, symbols, manipulatives and real-life situations (Figure 4), in order to present effective instructional content (Van De Walle, 2004). From this point of view, these five different representation forms have been determined as five sub-categories of the four main design decisions given above. In this way, mathematical tasks that are differentiated by symbol, model, text, visual elements not necessary for the solution of the task and visual elements necessary for the solution of the task associated with the mathematical task were designed within the context of this research proposal.

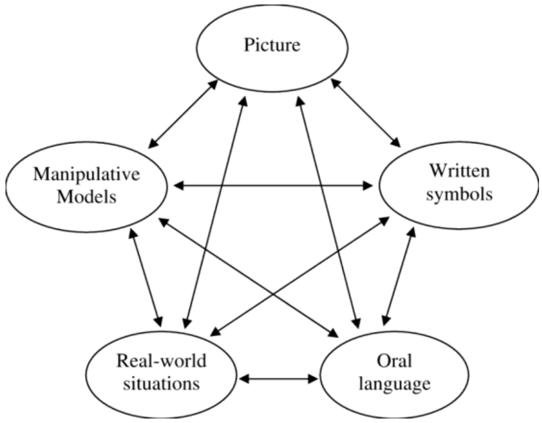

Figure 4. Five different representations of mathematical ideas (Van De Walle, 2004, p. 30)

These five different sub-categories compatible with the multiple representations model (Van De Walle, 2004) are identified for each main category and summarized below:

1. Mathematical task expressed by symbol (written symbols)
2. Mathematical task expressed by model (manipulative models)
3. Mathematical task expressed in text (oral language)
4. Mathematical task presented with text and visual elements not necessary for the solution of the task (picture)
5. Mathematical task presented with text and visual elements necessary for the solution of the task (real-world situations)

To sum up, as seen in Figure 5, within the framework of five different design principles to be used separately for each of the four categories, a total of 20 main mathematical tasks were designed.

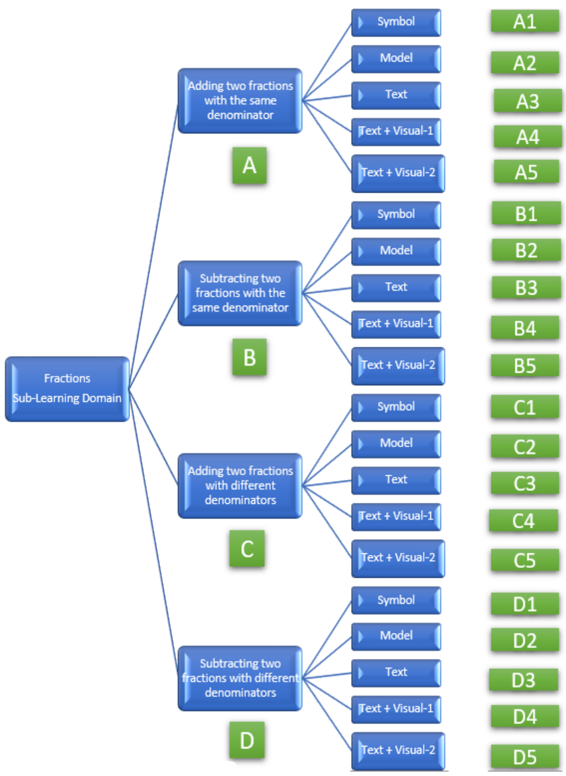

Figure 5. Categories of mathematical tasks associated with objectives and design principles

In addition to the design principles, sample tasks in line with these design principles were also prepared to be presented to mathematically gifted students in this research proposal. In order to minimize the misconceptions specific to the task, mathematical task examples have been diversified for each of the 20 specified tasks whose examples are illustrated in Figure 6 were designed. These examples were adapted from the sources of the Ministry of Turkish National Education and took their final form after the opinions of two mathematics educators and two experts in the field of industrial design within the framework of this study.

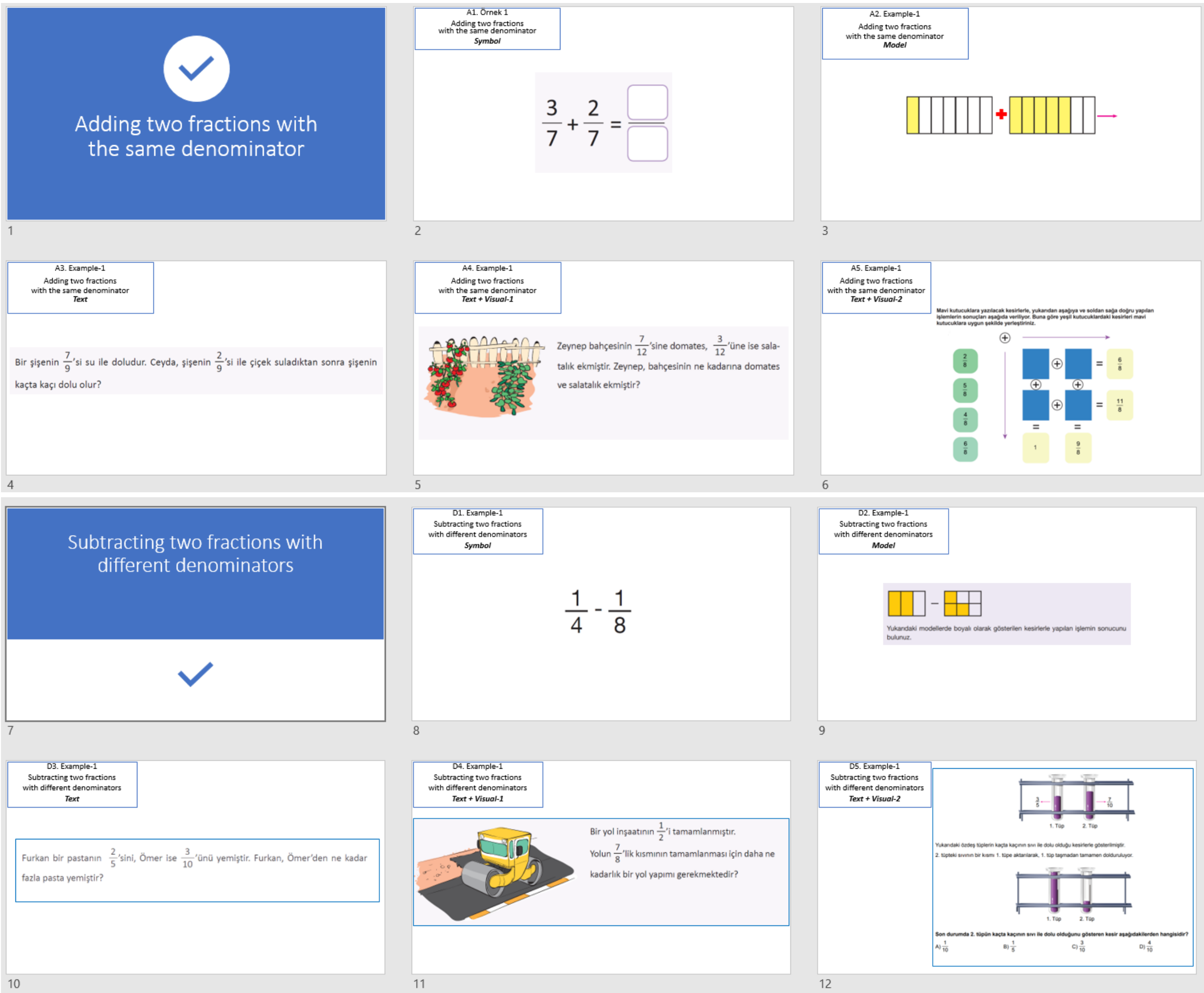

Figure 6. Examples of mathematical tasks

Study Procedure: Data Collection Strategies

Within the scope of this study, the designed mathematical tasks expressed above will be displayed to the mathematically gifted students on the computer screen, and their eye movements during this process will be recorded by means of eye tracking technology. Both quantitative and qualitative data collection are suggested for the triangulation of data.

Quantitative Data

Software of the eye tracker devices in which gaze metrics are recorded has the potential to facilitate the interpretation, analysis and expression of the data and produce recorded objective, quantitative and visual outcomes for researchers. It records all gaze activity information in pixels and millimeters when the eye is fixed or in motion, instant eye position and magnitude of pupils as well as mouse and keyboard movements of the user (Naschitzki, 2012; Bergstrom & Schall, 2014).

As stated before, fixations and saccades can give clues about what information people are paying attention to, they can show the cognitive process of users (Andrá et al., 2015; Jang et al., 2014). They can even help to predict:

1. Difficulties in acquiring information (Jacob & Karn, 2003)
2. High cognitive attention (Andrá et al., 2015)
3. Mental computation (Hartmann, Mast, & Fischer, 2015)
4. Intentions and future actions (Schindler & Lilienthal, 2017)
5. Boredom in looking (Schindler & Lilienthal, 2019).

Thus, in this study, it is recommended to examine the static (fixations) and dynamic eye tracking movements (saccades) of mathematically gifted students in the process of completing mathematical tasks. Concordantly, the data regarding the fixations and saccades are proposed to be used in the study to accomplish the following goals:

1. To reveal the features of the optimum visual content and design model that can be presented for mathematically gifted students.
2. To reveal the difference in the eye movements of mathematically gifted students during the review and completion of mathematical tasks by using the total time to first fixation, the total duration of first fixation, the total number of fixations, the total fixation duration time, the total number of visits, the total visit duration time, pupil dilation or shrinkage, and visualized gaze metrics (tracking maps) (Carbon et al., 2006; Marshall et al., 2014; Chen & Qiao, 2015).

The methodological framework established in this study draws theoretical insights from existing literature regarding eye tracking data, how to interpret it, and which eye metrics are critical for the related purpose. To illustrate, time to first fixation and first fixation duration provide profound insight into areas of the content that seem familiar or interesting, whereas fixation duration and number of visits give a clue about the interest and like (Bergstrom & Schall, 2014; Marshall et al., 2014; Ilhan & Togay, 2023). Moreover, some studies focus on pupil dilations, a vital indicator of the mental effort, stress, difficulty, or pleasure of solving a problem (Kahneman et al., 1969; Ho & Lu, 2014; Ilhan & Togay, 2023). On the other hand, visual maps like the tracking, heat or zoning maps can help identify specific places that users see and control are emphasized highly in the literature (Pascoe, 2008; Du & MacDonald, 2014; Hou & Lu, 2019).

Qualitative Data

Triangulation of the data by means of recall interviews or observation forms is recommended in eye tracking studies to support the quantitative data obtained from the eye tracking devices and examine the findings of the study more deeply (Holmqvist et al., 2011). Many user problems can be solved by supporting eye movement data with verbal expression (Paruchuri, 2012; Reid et al, 2012). Besides, eye tracking shows users' real-time reactions, while traditional methods such as interviews, observations, and surveys reveal feelings (Guo et al., 2016). Therefore, to make correct inferences about the eye movements of students, semi-structured/unstructured individual interviews and observations examining the student behaviors during the completion of the mathematical tasks are also proposed within the scope of this study.

Observations provide the data regarding attention points without interrupting the student during the application and without disrupting the eye tracking data. In that sense, the usage of observation forms prepared by determining the criteria that will allow the student reactions, gestures, mimics and behaviors to be noted is recommended for this proposed study. The data obtained through these observation forms can be used to compare/support the data gained from eye movements and these data can also be used in recall interviews to collect more in-depth data from the participant.

In these recall interviews, questions that can be shaped according to each student's individual process can be raised to the students after completion of the tasks. Then, these recall interviews can be recorded with audio/video recording. Here are some examples of the questions to be asked in the interview process of the proposed study:

"What are your thoughts on this mathematical task/application?"
"Was it interesting/boring? Explain with reasons."
"Which task did you enjoy more? Explain with reasons."
"Which task do you think was the one that you would enjoy dealing with in the classroom?"
"Which task has troubled you? Explain with reasons."
"Was it challenging? If so/not what effect does this have on you?"
"Were there any differences between this and the previous task? If yes, what kind of differences do you think they had?"
"Do you think you are good at these mathematical tasks? Can you explain with examples?"
"While observing your behaviors, I noticed that you … Can you explain the reasons for this behavior?"

In addition to these, the scales collecting the data regarding the students' subjective evaluations can also be used to triangulate the data obtained by gaze metrics. For instance, after completing each mathematical task, students may score the difficulty level and attractiveness of the tasks by using 5- point Likert scale as illustrated in Figure 7. The qualitative data obtained through this scale can be used as the nominal category for the quantitative analysis of eye movements.

1	2	3	4	5
Very Easy	Easy	Average	Hard	So Hard

1	2	3	4	5
Very Interesting	Interesting	Normal	Little Interesting	Not Interesting

Figure 7. Mathematical task rating scale

Proposed Empirical Experiment

Although the explanations presented in this research proposal remain theoretical, each is operationalized as a step-by-step empirical study guide. To classify participants and conduct comparative evaluations, all procedures are implemented within an experimental school setting concurrently with the systematic presentation of the proposal.

Students from a middle school in Ankara were selected using convenience sampling, a method commonly employed in qualitative research when considerations of time, cost, or accessibility are critical (Creswell, 2009; Etikan, Musa, & Alkassim, 2016). Subsequently, purposeful sampling was applied to identify mathematically gifted students, ensuring that participants selected could provide rich, in-depth information relevant to the study's objectives (Creswell, 2009; Etikan, Musa, & Alkassim, 2016). This approach allows the selection of students based on specific characteristics, in this case, mathematical giftedness. To determine eligibility, the Turkish adaptation of the Test of Mathematical Abilities for Gifted Students (TOMAGS) was administered. TOMAGS is a standardized, norm-referenced test with established reliability and validity for assessing the likelihood of mathematical giftedness (Ryser & Johnsen, 1998). Specifically, the TOMAGS-Intermediate form was utilized for students aged 9 to 11, as the focus of this study is on the topic of fractions.

Regarding sample size, the study aims to recruit a sufficient number of participants to allow meaningful statistical analysis. According to the central limit theorem, the arithmetic mean of a sufficiently large number of independent variables approximates a normal distribution. In practice, a sample size of more than 30 participants is generally sufficient for the distribution of means to approach normality (Tijms, 2012). Achieving this sample size will ensure statistical robustness and enable comparisons between mathematically gifted students and their peers.

Students' problem-solving processes and responses to various content, are being recorded with the aid of eye tracking technology, are triangulated with their verbal expressions, and the results are brought to the experimental setting by pairing the user, design, and eye data. While recording students' eye movements, the theoretical information from existing studies is helpful for presenting the content as visual mathematical problems to the students (Ilhan & Togay, 2020; Pei et al., 2022; Xiao & Wang, 2023). Studies in which participants examine images have shown that ideal presentation methods and presentation formats can be categorized under the following headings:

1. Visual tracking duration: In examinations conducted for varying or untimed durations, differences in duration do not significantly impact gaze order or focus. However, a uniform experimental design is recommended since varying durations are beneficial for analysis. More comprehensive qualitative assessments can be conducted when the participant determines the duration.
2. Repeated presentation: Gaze data have shown an increased tendency to seek out differences in comparative images and a decreased attention to familiar images. If repeated images are to be used in the study, it should be considered that the first viewing is the most intense.
3. Presentation order: When images are presented sequentially, a fatigue effect is observed, as attention decreases towards the end. Therefore, a random display order can be preferred to balance the viewing intensity.
4. Transitions between visuals: Leaving space between images is critical because it reduces the effect of previous viewing. A cursor positioned at a specific location on a blank screen focuses the participant's attention, prompting them to begin the following image from the same point.
5. Number of images: Participants can browse the entire image, regardless of the number of images. However, as the number of images increases, attention becomes more fragmented and comprehension decreases.
6. Layout: Whether images are horizontal or vertical on the screen does not affect participants' willingness to look at all the images.
7. Area of interest: Before starting experiments, researchers identify specific areas of visual content and divide them into focus areas, each distinct from the other. In this way, separate statistical evaluations can be conducted regarding each area of interest.

Therefore, this study proposal will structure its empirical study using this framework step by step.

RESULTS AND DISCUSSION

To conduct, organize and analyze quantitative, qualitative and triangulated data, some recommendations are described in this section.

Quantitative Results

The eye tracker software will record and keep the static gaze metrics quantitatively. These metrics that can be useful for this research proposal are listed below:

1. Total time to first fixation refers to the time it takes to focus on an area of interest for the first time. By using this metric, the information about when the student first contacted the task and the content shown to him/her can be obtained.
2. The total duration of first fixation refers to how long it takes for the initial fixation of gaze on an area of interest. By using this metric, the information about what first attracts students' attention when they see the content can be obtained.
3. The total number of fixations refers to the number of times the gaze is focused on the area of interest. By using this metric, the designers and educators can reveal the data on which specific parts of the content/task are focused more.
4. The total fixation duration time refers to how long the gaze is fixed on the area of interest. By using this metric, information about how long and where students exactly focus on can be obtained.

In addition to the above gaze metrics, dynamic eye movements such as gaze visit, pupil dilations, tracking path on the screen, instant position and gaze order are also obtained to understand the visual interests of students for each mathematical task.

1. The total number of visits refers to the total number of times the gaze passes over an area of interest while viewing it. By using this metric, the saccadic eye movements can be recorded to understand how many times the students visit or revisit a specific content.
2. The total visit duration time refers to the total time the gaze passes over an area of interest while examining it. By using this metric, the saccadic eye movements can be recorded to understand how long the students see the content.
3. Pupil dilation or shrinkage refers to instant measurements related to the diameters of the pupil. By using this metric, information regarding the students' stress or difficulties, whether they can cope with the problem or not, depending on the action can be obtained.
4. Visualized gaze metrics (tracking maps) refer to the analysis of eye movements, the path it follows, and the time it takes to look at a place. These metrics are also important for the correct interpretation of the content and various outputs can be obtained through the eye tracking process (Bergstrom & Schall, 2014). These outputs (whose examples can also be seen in Figure 2) proposed to investigate each student's eye movement while completing each mathematical task in the present study are given below:
   a. Fixation map can be obtained by the data where only the places the students look on the task are shown, and the other places are left in the dark. In this way, the seen places on the screen can be revealed and then, the content can be redesigned by putting the important information in these focus point locations.
   b. View heat map can create useful and easily evaluable visuals for the product/content designer of the proposed study. Obtaining a heat map for each content design can be interpreted as to which specific locations can be seen densely by the students. Heat maps will show the most

intensely viewed areas as red, intensely viewed areas as yellow, the less conspicuous as green, and the unseen areas as colorless.

c. View path map or tracking map can show the eye movement sequence, pattern and gaze length of students. The roadmap is created by numbering the views on the object starting from the number one to the last moment. The longer a student looks at a place on the task, the larger the diameter of the circle on which the sequence number can be seen. In this way, it can be revealed how students follow a path with their eyes while looking at a content and where they are stuck.
d. Zoning map can be obtained as a result of the analysis of the regions of interest. In this way, where the students look especially regionally and on specific districts of the tasks can be determined, and the contents that are desired to draw attention to those regions can be placed.

All the quantitative data obtained from gaze metrics and scales can be analyzed together in a structured way by means of appropriate statistical models. For instance, independent samples t- test or one-way analysis of variance can be chosen to reveal which data is significantly affected (how the eye behaves –i.e. fixation number on a specific location) depending on the number of groups differentiated by eye metrics on each area of interest or difficulty/interest levels in the scales. Moreover, correlation analysis can be preferred to question the relationship between the behavior of eyes and mathematical difficulty/interesting levels.

Qualitative Results

For the analysis of qualitative data, interview records can be transcribed to complete the first stage of descriptive qualitative data analysis. To reach a general conclusion about the meaning of the data, all the data obtained from the interviews and observations can be read and brought together. Then, qualitative analysis process, which can be carried out with the help of programs such as NVivo 9 or QDA Miner, etc., can continue with the coding stage by using the continuous comparative analysis method for more detailed analysis. After completion of the coding process, meaningful categories obtained from these codes can be created, which help to make interpretations reflecting the students' both cognitive and affective processes while solving mathematical tasks (Creswell, 2009). Additionally, students' comments can be evaluated for each mathematical problem and visual design using a 5-point Likert-based assessment of ease and interest. These questions' perceived ease or interest can be interpreted in relation to the design content.

Moreover, the inferences obtained through qualitative and quantitative data in this study process may provide triangulated findings on the optimum process model design and can be presented as study findings in a way that includes answers to all research questions. All assessments on a 5-point Likert scale can be examined in relation to all eye metrics by conducting a one-way analysis of variance and post-hoc analyses for all students. For example, by evaluating all students as a single group on a simple problem and its design content, eye metrics can be recorded, and statistically significant metrics can be calculated. On the other hand, using a t-test to separate gifted and non-gifted students into groups A and B, the Likert-scale responses can be used to determine and interpret how their gaze is recorded on the content.

Discussion

Gifted students represent valuable human resources for society, yet their abilities may remain hidden or manifest as behavioral challenges due to boredom with standard classroom content. Consequently, these students require differentiated educational materials that align with their cognitive characteristics and learning needs (Armstrong, 2021). Despite the recognized importance of supporting mathematically gifted learners, national and international literature reveals a limited number of studies targeting this population. In this context, designing appropriately structured instructional materials and examining them through the perspectives of mathematically gifted students may generate significant insights for both educational design and pedagogy. This research proposal emphasizes the potential role of eye-tracking technology and the integration of tailored visual design elements in investigating and validating assumptions about gifted students' learning processes.

Existing research predominantly relies on subjective measures, including students' self-reports, teacher observations, or researchers' interpretations. However, such methods may fail to accurately capture students' cognitive processes. Students may lack metacognitive awareness or be hesitant to articulate their thought processes due to shyness, anxiety, or fear, leading to incomplete or inaccurate data (Schindler & Lilienthal, 2018). Eye-tracking technology provides an objective method to measure learners' visual attention and information processing in real time, offering more direct insights into cognitive engagement than conventional self-report or observation methods (Keinonen, 1998). This technology is particularly valuable for accessing latent or otherwise inaccessible information, such as instances when students forget where they are looking, ignore certain content, or cannot verbally express their focus (Guan, 2007; Miller, 2017; Rojas et al., 2020).

Eye-tracking also mitigates the effects of verbal expression limitations, social expectations, and environmental influences on recall or self-reporting. Consequently, it is a recommended tool for investigating students' cognitive processes, particularly for specialized populations like mathematically gifted learners (Andrá et al., 2015; Salvucci & Goldberg, 2000; Schindler & Lilienthal, 2018). In addition, eye-tracking data can reveal which elements of instructional content attract or fail to attract attention, thereby facilitating the development of individualized, user-focused educational materials and data-driven interventions aimed at enhancing engagement and learning outcomes.

Despite its advantages, the application of eye tracking presents methodological and ethical challenges. First, the assumption that eye movements directly correspond to cognitive processes is not always valid. For example, prolonged fixation on a specific area may reflect distraction, confusion, or scanning behavior rather than deep cognitive engagement. Therefore, triangulating eye-tracking data with complementary qualitative methods is essential to ensure valid interpretation (Paruchuri, 2012; Reid et al., 2012). Similarly, presenting content for durations exceeding 20–30 minutes may induce fatigue or distraction, potentially compromising data quality.

Individual differences in cognitive style, prior experience, and task strategies can also limit the generalizability of eye-tracking findings. To address this, participants' abilities should be assessed and categorized—for instance, using standardized measures such as the TOMAGS test for mathematical ability (Ryser & Johnsen, 1998)—enabling reliable comparative analyses across relevant subgroups.

Technical and logistical challenges arise when conducting eye-tracking studies in naturalistic educational settings. Fixed equipment, restricted mobility, data loss, and measurement inaccuracies can threaten reliability, particularly with younger participants. While laboratory-based experiments offer controlled conditions, they may compromise ecological validity. Researchers must therefore balance participant characteristics, study objectives, and contextual constraints to optimize the validity, reliability, and generalizability of results (Creswell & Miller, 2000; Hudlicka, 1996; Kjeldskov & Skov, 2014; Kuniavsky, 2003).

Eye tracking technology has critical importance in providing design opportunities and insights that have not been gained so far in mathematics education research (Schindler et al., 2016). Through the background part of this study, the contributions of eye tracking technology to make inferences about content design in the fields of both mathematics and gifted education could be seen clearly. However, the deficiencies in the studies examining the processes of mathematically gifted students from the design perspective with the help of eye tracking technology were also noteworthy. Based on this gap and the importance of the design aspect in education (Mofield, 2020), this study proposed to produce solutions for the needs of mathematically gifted students. In line with this aim, the data that may obtained from the time spent with the content, the order in which the content is examined, the interpretation of the viewing data were thought to shed light on the process of designing the instructional content. Thus, it was predicted that designing the tasks of mathematically gifted students and making inferences through their eye movements might provide information about:

1. How students see and track the content design and instructional material (through the metric data obtained from eye fixations such as total time to first fixation, the total duration of first fixation, the total number of fixations, and the total fixation duration time)
2. Where students start and how they complete the process while reading the information in mathematical tasks, where they look at and how long time they spend (based on saccadic movements such as the total number of visits, the total visit duration time)
3. Which regions the students focus/hesitate on mathematical tasks (through pupil dilation or shrinkage and visualized gaze metrics such as fixation map, view heat map, view path map, and zoning map outputs)
4. Which model design and design principles should be implemented for the tasks of mathematically gifted students (based on the quantitative data obtained from gaze metrics and qualitative data obtained through observations and recall interviews)

Finally, the use of eye-tracking technology entails important ethical considerations. Given that eye movements can reveal highly personal cognitive and attentional patterns, voluntary informed consent and strict data privacy protocols are essential, particularly for vulnerable populations such as children or clinical groups. Moreover, researchers must remain vigilant to avoid unethical outcomes, including labeling or discriminatory practices that could arise from differential assessments of gifted and non-gifted students.

CONCLUSION

In summary, in this research proposal, a comprehensive literature review regarding the contribution of eye tracking technology to design instructional content for mathematically gifted students was presented. Then, design decisions and related mathematical tasks were determined within the framework of this literature synthesis. Based on the advantageous position of eye tracking technology in providing methodological efficiency for instructional design studies, a research study to examine the eye movements of the mathematically gifted students experiencing these designed mathematical tasks was proposed. Moreover, the data provided by the usage of eye trackers were recommended to be triangulated by observation and recall interviews. By means of this proposed study, a roadmap that supplies information for both design and mathematics education researchers concerning how an optimum mathematical task should be provided can be obtained.

This study highlighted the importance of systematical understanding and revealing the hidden interests of the students by examining their gaze behaviors, which can be used as a basis for future studies. After carrying out the experimental study of this proposal and obtaining its outputs, it can be helpful for design researchers and instructional designers to create educational content and make product decisions according to visual data analysis. In this way, it can be possible to make inferences about these students' eye movements on the tasks, compare different task designs, and suggest optimum design principles for the specific tasks. Moreover, it can provide a useful guide for educators in order to understand the responsive patterns of mathematically gifted students while experiencing their mathematical tasks. Besides, it can also be a roadmap used for gifted students in different fields for upcoming studies.

The theoretical and practical recommendations of this proposal offer interesting insights for future research. This study, which proposes how eye-tracking technology can more comprehensively examine the validity of pedagogical and cognitive assumptions in the field of gifted education, how to interpret recorded eye metric data, and how to compare these with qualitative assessments, presents a powerful opportunity for educators and researchers. However, combining this potential with technical capacity and methodological rigor, contextual awareness, and ethical sensitivity will be important. In the future, this technology can be used more comprehensively with other neurocognitive research or through interdisciplinary collaborations to develop systematic models. It would not surprise us to see cognitive data collected from users soon, processed as big data, and interpreted with intelligent technologies such as machine learning. The rapid integration of artificial intelligence into education and design could enable student identification and classification, design of educational content specifically for them, and support personalized learning environments. This potential could lead to increased educational efficiency and equal opportunities for both educators and students.

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Declarations

Author Contribution	:	AEİ and DÖ: Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Project Administration, Resources, Software, Supervision, Validation, Visualization, Writing - Original Draft, and Writing - Review & Editing.
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