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Literature Review on Mathematics Education with an Emphasis on the Creative Process

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ABSTRACT
Mathematics is a mandatory subject for elementary and high school students. The capacity to think critically and make connections across different areas of study are other characteristics of this field of study. In this area, gifted children shine because of their diverse question sets, innovative ideas, and multi-pronged problem-solving strategies. Their intellectual growth may be greatly enhanced by providing them with opportunities to refine their skills. This article provides a literature review on mathematics instruction for gifted kids. In order for bright pupils to reach their full potential, the book stresses the need of providing them with opportunities for growth. The essay explores a range of instructional strategies, such as using GeoGebra and mathematical modeling in the classroom. This paper highlights a comprehensive approach to gifted education that includes methods for identification, specific training for teachers, and sufficient resources and support systems. Additionally, the paper contends that talented kids should have their education prioritized and looks at the difficulties gifted students have. The purpose of this article is to discuss effective strategies for tutoring very bright math pupils and to provide suggestions for doing so. Thus, this research aims to conduct a literature review to discuss educational opportunities for brilliant and gifted children and the contemporary resources that may be used for this purpose.

keywords: gifted students, mathematics, mathematical modelling, personalisation

1. Introduction

Although students with special needs often get individualized attention and crucial assistance, it is crucial to acknowledge that talented students do not always receive the same level of care. The general quality of education in society suffers as a result of this omission, which has a devastating effect on the growth of future thinkers.

1.1. Definition of Gifted Students

The literary community as a whole has wildly divergent views on what constitutes true skill. The articles' authors contend that great instructors may have a positive and enduring impact on their students' mathematical creativity, growth, and achievement, and so highlight the importance of teachers in gifted education. Teachers of very talented kids are required to exhibit certain traits. Teachers need to be able to do things like correctly gauge their students' strengths and areas for improvement, deliver material in a way that motivates and challenges them, provide constructive feedback and opportunities to adjust their strategy, and encourage students to rely on themselves and their own abilities (Khalil and Accariya, 2016). Therefore, it is far from an easy task to instruct gifted children. Achieving outstanding results and developing innovative strategies that are praised for their greatness or novelty are both results of developing one's potential. Outstanding individual

is someone who stands out from the crowd in a certain field, surpassing average performance rather than the majority (Bezić, 2019).
According to Bezić (2019), gifted pupils are defined as individuals who exhibit exceptional traits in: Convergent thinking is an example of this in the intellectual sphere (whether broad or narrow), - in the realm of education (both broad and narrow),
- in any creative endeavor (the arts, sciences, technology, or athletics), as shown by the presence of novel ideas, adaptability, fluency, and diverse thinking,
- Skill in a creative area (such as the performing arts, visual arts, literature, cinema, or music),
The ability to move one's body and mind interpersonal competence,
• Managing one's own thoughts, feelings, and motivations (metacognition). The ability to think creatively, shared by some exceptionally talented individuals, entails an entirely new way of thinking when it comes to solving problems, interpreting problems, drawing mathematical connections, applying techniques, and generally coming up with fresh ideas. Basically, when you need to come up with fresh solutions to old issues, you have to be creative (Leikin, 2011).

When considering the interests, skills, and developmental trajectory of a group, it is important to pay particular attention to gifted and talented youngsters. Putting their education first will ensure that their unique developmental requirements are met and that they have access to opportunities inside the classroom that are a good fit for their skills. Recognizing that identifying, assessing, and guiding these students is an intricate process is also crucial for their education.

In most schools, kids who are considered brilliant or talented attend regular classes with their normally developing classmates. They could or may not make the most of the chances presented to them in these settings. The significance of our research, which seeks to investigate the educational opportunities for brilliant and talented youngsters, is highlighted by this predicament. In particular, we want to investigate how these exceptionally talented students might be best guided in their education and how contemporary pedagogical resources can be used to enrich their educational experiences (Baykoç et al., 2014).

1.2. Literature Review

How can we best meet the unique needs of exceptionally gifted students? Scientists have not yet found a satisfactory solution to this mystery (Mofield, 2020). This effort is especially important since gifted children are often enrolled in mainstream classes without receiving the individualized attention they need to develop their unique set of abilities, passions, and character attributes (Brigandi et al., 2019).
Research into creativity has led to the development of a plethora of creative strategies, such as approaches to problem-solving and brainstorming. Making individuals more creative, and especially better at generating new ideas, is the end goal of all of these methods. In today's technologically enabled world, there are considerably more contemporary alternatives to education than the traditional paradigm that relied heavily on students and instructors meeting in person. Learning has been revolutionized in today's schools with the introduction of computer-based learning environments. Given the urgent need for creative problem solvers in today's society, it is imperative that we study the role of schools that integrate computer education into their syllabi (Aqda, 2011).
Scientific evidence supports a teaching strategy in which teachers design lessons with all students, including the most gifted, in mind. Teachers use this method to elucidate concepts and inspire pupils to think critically about novel approaches. The goal of both formative

and summative assessment is to give students opportunities to show what they can do with higher-order thinking skills, such as coming up with their own problems, seeing patterns, coming up with their own solutions, and combining different mathematical ideas. Instructors may also serve as role models for enthusiastic mentors by demonstrating that they take pleasure in guiding students through challenging problems and understand the value of making mistakes. Singer et al. (2016) states that when teachers show they like solving problems, it makes the classroom a better place for pupils, who are then more likely to be resilient, creative, and have an appreciation for mathematics. Research is increasingly highlighting the significance of students' perspectives on their academic performance. The fact that pupils firmly believe that their academic abilities are either permanently fixed or subject to change is becoming more clear. Additionally, studies have shown an intriguing trend: both teachers and students in mathematics tend to ascribe greater success to innate talent than in other subjects. Be that as it may, rigid beliefs on the essence of mathematical ability may have prevented researchers from considering the potentially unique effects of mindset therapies in mathematics. Differentiated education is one of the new pedagogical approaches. According to Tomlinson (2014), this is the only way for students' interests, abilities, levels of preparation, and learning profiles to be actively considered when designing lessons. In this respect, technology is essential. Essentially, teachers may equip their outstanding children for success in the contemporary world via the use of technology. This includes teaching them to think critically, solve issues on their own, and self-regulate.

The use of artificial intelligence (AI) technology to simulate instructors' expertise is one promising alternative that has attracted much attention. According to Poui et al. (2021), Xiao and Yi (2021), and Hwang et al. (2020), this might result in individualized support and direction for students.

2. Method

For this literature study, we scoured authoritative databases including Sage, Elsevier, ProQuest, and Taylor & Francis for peer-reviewed papers. We set out to learn more about the ways mathematics is taught and the resources that are available to teachers today so that we might better understand the context of mathematical talent throughout the world. We used straightforward keywords pertinent to these areas of interest to efficiently traverse this massive corpus of literature.
There was an effort on our part to exclude items that addressed certain age groups, kind of educational institutions, or levels of learners (e.g., elementary, secondary, or upper secondary). Articles have to include the word "gifted learners" anywhere in the text, be titled with a particular nation, and have been published no earlier than 2010 to meet our primary inclusion criterion. This methodical strategy guaranteed that While keeping a wide scope for thorough analysis, our evaluation offered a thorough overview of pertinent and up-to-date literature.

2.1. Purpose of the Study

This article aims to provide a comprehensive review of the literature on giftedness and gifted education, with a particular focus on different global contexts. We aim to present a nuanced perspective by exploring how authors from different countries articulate the nuances of mathematics education for gifted learners.

This exploration involves a multifaceted examination of how these representations are manifested, recognising that differences may manifest themselves in different ways. This review focuses on distinguishing the unique barriers faced by individual countries and

understanding the multiple ways in which these challenges affect different stakeholders at different levels of education.

3. Results

Some researchers are exploring interventions involving contextual personalisation, a teaching strategy that aligns curriculum content with students' interests in areas such as sport, cinema, or gaming. It's worth noting that the extent to which students are quantitatively immersed in their areas of interest, and the extent to which problem-solving tasks are designed to reflect how students engage with their areas of interest, play a key role in the successful implementation of personalisation in an AI-driven learning environment (Walkington & Bernacki, 2019).

In a study by Hooshyar, an innovative approach was used that included an online game-based formative assessment within a flowchart-based intelligent tutoring system. The research results showed a remarkable change in the 52 university students who participated. Their interest in learning, attitudes and performance in computing were significantly improved following the learning activity. In addition, the results showed a clear advantage for the experimental group in using effective help-seeking strategies, surpassing the performance of the control group. This suggests that adaptive learning systems have the potential to significantly improve students' overall learning outcomes and performance compared to traditional computer-based learning systems (Hooshyar et al., 2016).

The effectiveness of a learning agent in an educational context has been the subject of various research efforts. This educational software, called learning agents (LA), implements the pedagogical approach of learning by teaching. In this approach, the human learner takes on the role of the teacher, instructing the teaching agent and, in the process, deepening his or her understanding (Gulz et al., 2020).

Numerous studies have explored the integration of agent-based learning games into school settings, highlighting the pedagogical potential of LA-based games. This research has consistently demonstrated the significant benefits, which include both improved learning outcomes and increased student motivation (Pareto et al., 2012; Lindström et al., 2011). The use of LA-based games has shown promise in improving various facets of learning, including increased time spent learning, increased willingness to review material, increased propensity to seek additional information, improved conceptual understanding, enhanced metacognitive abilities, increased task completion rates, and more (Gulz et al., 2020).

There is a notable emphasis by researchers on the concept that has been brought to light - the importance of differentiated instruction using technology as a versatile teaching strategy. This approach enables educators to tailor their teaching methods, thereby promoting opportunities to meet the unique and varied needs of each student (Alshareef et al., 2022). Differentiated Instruction stands out as an approach to teaching that introduces a significant degree of adaptability into educators' practices. It enables them to dynamically adjust the curriculum in response to students' characteristics, which include factors such as their abilities, readiness, interests and learning profiles (Tomlinson, 2014).

Useful Technology has a dual role to play in education. Not only does it help teachers differentiate instruction, but it also serves as a valuable pedagogical and creative tool for the most advanced and gifted learners (Periathiruvadi & Rinn, 2012). In essence, technology enables teachers to equip gifted and talented students with essential 21st century skills such as critical thinking, problem solving and self-regulation.

Many applications are not only popular, but also provide valuable tools for research purposes. These applications include Symbolab, GeoGebra, Maths Solver, iMathematics, Cymath, WolframAlpha, QuickMath, Microsoft Math Solver, Chegg Math Solver, MathPapa, Maple

Calculator, Tiger Algebra, Gauthmath, GeoGebra and similar options (Booc et al., 2023). The versatility of these applications makes them well suited for inclusion in the mathematics curriculum for gifted students.

3.1. Teaching Mathematics for Gifted Students

Regular participation at professional development activities such as conferences, seminars, meetings, and specialty training is essential for math educators, as is continual research of emerging developments in the area. By keeping up with the latest research on student success, educators who practice lifelong learning are better equipped to enhance their classroom methods. Teachers should use their imaginations when choosing examples to teach from if they want to connect with their students on a deeper level. Mathematical understanding and interest may be enhanced when teachers guide pupils in drawing parallels between abstract concepts and real-world applications. In addition to fostering students' critical thinking skills, this method of teaching mathematics helps them become more integrated into society. Mathematics goes beyond exam prep when it is meaningful and applicable to real life. It is the responsibility of educators to help students develop their strengths while also giving them real-world examples to help them understand the material (Algani, 2019).

Coe argues that new approaches, such as crosswords, magic squares, and decoding, are necessary to make mathematics more engaging. She places an emphasis on mathematical fun, in which students use tools like mazes and knowledge maps to sequentially apply different calculations and concepts in order to develop links. Additionally, Coe stresses the need of contemporary instructional methods. Teachers should find strategies to help students work together as a team because of the positive effects that have been shown (Coe, 2018).

Computational modeling for mathematical problems may be beneficial for students, as it promotes independent investigation, data analysis, and critical thinking (Lin et al., 2017).

Students must learn to construct representations as they engage with mathematical models. Since the concept of creating representations corresponds to the highest level of Bloom's Taxonomy, it will be an appropriate and intellectually stimulating pursuit for students with exceptional mathematical abilities (Irvine, 2017). According to Lesh et al. (2000), mathematical modeling takes mathematics out of the abstract and into the realm of real-world mathematical interactions, which helps to promote a deeper understanding and synthesis within the discipline. Mathematical modeling in the form of model elicitation tasks is known to foster originality and be an invaluable resource for students with natural mathematical aptitude (Gilat & Amit, 2013). In addition to fostering original thought, this method is useful for spotting and supporting children who have extraordinary mathematical creativity. Mathematical modeling exercises promote mathematical development and synthesis on a more fundamental level by mimicking mathematical interactions in the real world. Kozlowski and Chamberlin detail in their 2019 article what happens when... Using multiple-solution activities is another tactic for teaching very intelligent kids. This approach encourages students to generate novel ideas and approaches (Levenson et al., 2018).

Use open-ended questions while working with mathematically talented kids. These questions foster critical thinking, multiple-choice responses, and the consideration of other viewpoints (Levenson et al., 2018). After conducting a thorough investigation, Basister and Kawai (2018) discovered shared characteristics across mathematics talented classes in Japan. The investigation discovered something that all of these classes had in common. It is recommended to include open-ended activities and inquiries, as pointed out by Basister and Kawai (2018). To meet the specific needs of gifted students, this approach to education promotes an environment rich in mathematical exploration. The approach's basic open-

ended problems inspire students to employ a range of mathematical talents and their imaginations. Not only do these issues promote analytical thinking, but also provide gifted kids a strong basis to develop their mathematical abilities, which in turn opens up a world of opportunities (Kozlowski & Chamberlin, 2019).

3.2. Modern Tools for Teaching Mathematics

3.2.1. Primary School

Olafenko and his team reported using interactive exercises from Learningapps.org. These exercises allow users to engage in practical activities such as arranging items in the correct order, selecting the correct answers, solving crossword puzzles, tackling various puzzles, and grouping elements. The platform offers many templates for trainee teachers and a library of pre-designed interactive exercises that can be used as templates. These resources are a great help in creating didactic exercises suitable for specific grade levels and topics of study. In addition, completed projects can be conveniently saved either locally or on a network (Olafenko et al., 2019).

GeoGebra is very popular and useful nowadays. It is a dynamic geometry package. You can construct points, vectors, distances, lines, cones, and functions - all elements can then be modified dynamically. On the other hand, we can enter algebraic equations for lines and cones, coordinates, and numbers. All objects can be calculated, so we can already speak of CAS systems for these objects. These two functions are a special feature of GeoGebra. An expression in the algebra window corresponds to an object on the board and vice versa. This is also the input case - either by selecting the appropriate input mode with the mouse on the drawing area, or by typing the appropriate command on the command line. GeoGebra was written in Java, which allowed the creation of applets that could be easily published on the web by integrating the applet using a Java plug-in. As this technology was dying out in web browsers, the creators of GeoGebra updated the system with a JavaScript compiler at the right time. As the source code has remained Java, it is now possible to create all applets in the web version of the program, upload them to your web server and then embed them in your web pages. GeoGebra gives an overview of the planar and analytical content of point sets, which are most often considered in the plane. It is translated into several languages (Olafenko et al., 2019, Tamam & Dasari, 2021, Kramarenko et al., 2020, Suryani & Rofiki, 2020).

Problems with the square and the volume of shapes can be programmed in Geogebra. The task is to find which of the figures has the largest width and volume. These can be text problems of the type "connect the dots". The result is a Christmas tree (Olafenko et al., 2019).

Özçakir's study used GeoGebra as a learning tool via tablets. In these activities, they only moved the points and line segments by touching and dragging (Özçakir et al., 2020).

3.2.2. Secondary School

Das emphasises the importance of incorporating information and communication technology (ICT) into mathematics teaching, highlighting two valuable tools: Maxima and SymPy. Maxima is an algebra solver based on the Lisp computer language and compatible with various POSIX platforms such as Linux, Unix, OS X and BSD. It uses Gnuplot for graphical visualisation. On the other hand, SymPy is a Python library designed for symbolic mathematics. Its goal is to evolve into a comprehensive computer algebra system (CAS), while keeping the code simple for better understanding and extensibility (Das, 2019). These two tools are used alongside the classic spreadsheet for simple calculations. They can also be used to draw graphs, solve quadratic equations, draw common geometric figures such as triangles, cubes, etc. or trigonometric angles, for example to measure distances in real life (Das, 2019).

When teaching gifted students, it's important to encourage interactivity and engage them in enriching activities. Incorporating collaborative learning experiences is key. For geometry-

focused tasks, the use of tools such as Wolframalpha, Maplesoft, GeoGebra, Sketchpad and Cabri can greatly enhance the learning process. These resources are valuable not only for hands-on geometry activities, but also for effective demonstrations and comprehension exercises where appropriate. Incorporating interactive applications such as Geogebra Graph and Desmos can bring mathematics to life by modelling real-world situations and allowing students to draw meaningful conclusions. It is also important to create a dynamic learning environment with room for questions and discussion. The use of applications such as Quzizz, FlipQuiz and Kahoot Classic Mode can facilitate engaging Q&A sessions and stimulate fruitful discussions among gifted students (Cildir, 2020).

In Liburd's investigation, students used GeoGebra to find the intersection of the graph of linear functions, the x-intercept and the y-intercept, to find the slope of a line, to find the equation of a line, to solve problems involving the slope of parallel and perpendicular lines, to find (a) the length and (b) the coordinates of the centre of the line from the distant coordinates, and to draw the graphs of linear functions (Liburd & Jen, 2021).

3.2.3. Faculty

Notable examples of tools that foster mathematical computational thinking are NetLogo and Mathematica, which are discussed in many scholarly studies. One of the most effective resources for enhancing mathematics teaching and cultivating computational thinking is NetLogo, a program for computational modeling. Mathematica is an additional helpful tool for both students and educators. Students may enhance their computational thinking abilities by exploring methods developed to address intricate computational issues inside this computer algebra framework, as shown by (Jun & Yoon, 2016, Jun, 2020). Using Symbolab Math Solver for integral calculus and Desmos for graphing, Rézio suggested educational difficulties. Differential calculus, integral calculus, and series were the three subjects taught in the first chapter. Counterflow and area computation were part of the curriculum of integral calculus, the unit where this educational challenge is contained (Rézio et al., 2022).

More than 9 million people use Mathway every month, and over 1.3 billion problems have been answered using it, according to Booc. With over 200 million users globally, Symbolab easily outpaced Photomath's 6.5 million monthly users. Bitter and Corral (2015) listed a number of additional mathematical applications, including: iMathematics, Cymath, Microsoft Math Solver, Chegg Math Solver, MathPapa, Maple Calculator, Tiger Algebra, Gauthmath, GeoGebra, and others (Booc et al., 2023).

According to Frieder's study, which is one of many assessments of the popular ChatGPT, the program really shines when used as a mathematical assistant for simple fact-finding jobs, essentially functioning as an interface between a mathematical search engine and a knowledge store. Undergraduate mathematics students will find it very helpful. Nevertheless, GPT-4 and ChatGPT both underperform when confronted with more intricate mathematical problems requiring a graduate-level education. While GPT-4 and ChatGPT have received a lot of good press for their problem-solving abilities, especially in exam-like scenarios, their general mathematical proficiency falls short of what is expected at the graduate level (Frieder et al., 2023, Plevris et al., 2023).

In addition to providing thorough instruction and study aids for geometry, public discourse on social media platforms is often upbeat and enthusiastic over the use of ChatGPT in educational and mathematical contexts. Still, some people are wary of it. Wardart's research looked at how three different learning environments affected the user experience. ChatGPT isn't very well-versed in geometry, therefore it can't clear up misunderstandings. How well and accurately ChatGPT solves problems may rely on the input data, the difficulty of the equation, and the instructions provided to the software. ChatGPT's remarkable math skills have been on display in its capacity to effortlessly solve difficult calculus problems and manipulate algebraic equations. Further, integrals, derivatives, and differential equations

are examples of more complex mathematical problems that ChatGPT has shown capable of handling.

4. Discussion and Conclusion

Findings from studies repeatedly stress the need of adapting lessons for talented pupils. There are three main types of customized tasks: mathematical modeling, open-ended, and multiple-choice. For kids who are naturally talented in mathematics, these kinds of activities are great for encouraging their imagination and helping them grow as learners. And it's not just the exceptional kids that gain from these assignments; the rest of the class also has a great chance to learn from them. These exercises allow students, even those working on their math abilities, to interact with mathematical information in a manner that works for them because of their unique qualities, such inventiveness, flexibility, and fluency. they are capable of learning and how they learn best. According to Kozlowski and Chamberlin (2019), this method of designing tasks is inclusive since it allows all students to study mathematical topics in a manner that is suitable for their own needs and abilities. An interactive and engaging pedagogical approach is necessary to support gifted learners' educational journey. Consequently, including collaborative learning experiences is a crucial tactic. Scientific studies have shown that children learn best with mathematical modeling, computational modeling, mathematical entertaining, and open-ended, multi-solution activities. Finally, the first study question—how to best educate exceptionally bright students—has been answered.

Geometry education might reach new heights with the help of programs like WolframAlpha, Maplesoft, GeoGebra, Sketchpad, and Cabri. They are great for practical geometry exercises and demonstrations, and they also help with understanding tasks when you need them.

Teachers may take use of these adaptable tools to design engaging lessons that extend beyond the four walls of the classroom. The use of dynamic interactive programs like Geogebra Graph, Desmos, and Symbolab also adds life to mathematics lessons. Students may use these apps to simulate real-life situations, which helps them gain valuable insights and understand how theory relates to practice.

Incorporating chances for inquiry and debate is crucial in the search for a dynamic and engaging learning environment. In this context, apps like Quizizz, FlipQuiz, and Kahoot Classic Mode are useful since they allow for interactive question and answer sessions and promote robust conversations among talented students. Not only can these tools make math more engaging, but they also provide students the tools they need to be active participants, ask questions, and go deeper into the subject.

In recent years, artificial intelligence (AI) has shown to be an invaluable tool for math educators. Tools driven by artificial intelligence can adjust to each student's particular learning style and speed, creating individualized courses and activities that push talented individuals to their full potential. In addition to monitoring development and offering immediate comments, these resources help personalize and captivate the educational process. To pique the interest of talented math students, educators have turned to a range of instructional games. Mathematical reasoning may be stimulated by these games' dynamic and engaging experiences, which blend enjoyment with learning. Mathematical scenarios, riddles, and problem-solving challenges are common components that aim to spark imagination and analytical thinking. Some software, like Mathematica and NetLogo, has come under scrutiny for the ways it has impacted mathematical teaching. Students' computational thinking abilities are enhanced by using NetLogo, a computational modeling program. However, students of mathematics, particularly calculus, can benefit from Mathematica's computer algebra system by investigating intricate mathematical algorithms (Jun & Yoon, 2016). An new method of teaching mathematics is learning agent-based games. Students often act as instructors in these games, providing instructions to a virtual

learning agent. As they go through the process, students not only improve their problem-solving and teaching abilities, but also their grasp of mathematical topics. A pedagogical strategy that caters to students' diverse needs is differentiating instruction. Differentiation in mathematics education for talented students entails tailoring the course's content, tempo, and difficulty to meet their individual needs. This method guarantees that talented students are constantly involved and faced with new mathematical challenges. Gifted students in mathematics are best promoted through different approaches to problem-solving and posing, discourse and questioning, creativity, and innovation, challenging mathematical tasks, curricula and textbooks, in-school programmes and activities (in terms of ability grouping, self-contained classes and specialised schools, acceleration and promotion) and out-of-school programmes and activities (in terms of recreational mathematics and competitions) (Singer et al., 2016).

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