

USING CHATGPT IN TEACHING INTEGRAL CONCEPTS: OPPORTUNITIES AND CHALLENGES

NOUROOZ HASHEMI^{ORCID} AND HAMIDREZA KASHEFI^{ORCID}*

ABSTRACT. This study presents an analysis of the mathematical abilities of ChatGPT in solving problems in the process of teaching integral concept with different thinking levels based on Bloom's taxonomy by thematic analysis method. The integral concept was designed in the form of 20 problems in six levels of thinking from Bloom's perspective. The problems were asked by students of the first year of mathematics from ChatGPT under the supervision of the researcher as a teacher. The results show that the performance of ChatGPT varies depending on the difficulty level and the topic and the level of Bloom's thinking. He had the best performance in answering the level problems of remembering and analyzing, and he showed very weak in answering the problems of evaluating and creating. Also, the results showed that ChatGPT does not pay attention to written details such as parentheses and brackets. Accurate long calculations, correct use of integration rules, classification of integral types were the strengths of using ChatGPT in integral education. He was unable and had many defects in drawing a figure, presenting a graph related to a function, generalizing the integral to higher dimensions, and understanding that an integral should be used to solve a problem. Also, as the levels of thinking increased, its efficiency was decreasing. The results show that ChatGPT has the potential to become an effective teaching aid tool for integral teaching, but its graphic capability should be increased and its data processing should be improved and its shortcomings should be eliminated.

Keywords: ChatGPT, Training, Integral, Problem Solving, Bloom's taxonomy.

Article Type: Research Paper.

Communicated by Saeid Maghsoudi.

*Corresponding author.

Received: 12-02-2024, Accepted: 20-05-2024, Published Online: 25-01-2025.

Cite this article: N. Hashemi and H. Kashefi, Using ChatGPT in Teaching Integral Concepts: Opportunities and Challenges, *Journal of Mathematics and Society*, **9** no. 4 (2024) 1-22.

<http://dx.doi.org/10.22108/msci.2024.140698.1646> .

1. Introduction

The teaching of mathematical concepts in any course is one of the main concerns of educators and policy makers of education, and according to the conditions of that course, different strategies have been used for its teaching [20, 22]. From the past until now, calculus has been of great importance as one of the most important mathematics courses for undergraduate students in many fields of study [19, 2, 1, 36, 37]. This course has been one of the most fundamental and important courses, not only in the bachelor's degree in mathematics, but also in various fields of basic science and technical and engineering [9, 31, 34, 24]. Integral is one of the fundamental concepts in calculus that undergraduate students encounter in the first year, and it is a prerequisite for learning other mathematical and non-mathematical concepts such as physics, chemistry, etc [38, 7, 9, 26]. In different fields of study. In fact, the difficulty of students in integral learning is closely related to the inability to solve problems, which is one of the skills of the 21st century. Also, the problem solving process plays an important role in the progress of learning mathematical concepts [11, 13, 15, 12, 17, 23, 24].

In recent years, artificial intelligence (AI) has attracted much attention and has been widely discussed. Strongly promoting the use of technology and technological networks in teaching mathematics based on artificial intelligence is not only an effective way to solve the lack of educational resources, but also a bold attempt to innovate the methods of teaching mathematics in schools and universities [3, 8]. Artificial intelligence represents a creative and innovative development in many fields, including mathematics education, which has the potential to be combined with various theories of mathematics education for implementation in classrooms. Many studies have studied the application of artificial intelligence in the fields of education and analyzed its impact on the education of various sciences, especially mathematics education. Of course, it should be noted that the role of teachers and educators should not be replaced by artificial intelligence in the educational process, but artificial intelligence should be used to strengthen their activities [27, 29]. It should be noted that the implementation of artificial intelligence in mathematics education has always faced various challenges despite its potential benefits. From 2022, in order to solve the challenges and minimize them, the ChatGPT platform has provided a space for the optimal use of artificial intelligence in education, especially mathematics education [39].

The basic needs are to transform an education into an efficient, high-quality and effective education based on the use of modern education methods and tools [41, 43, 45, 23]. Today, comprehensive improvement of teaching quality is the highlight of mathematics education, and integral teaching in undergraduate courses is no exception to this rule. The use of modern teaching methods and up-to-date educational tools can be effective and useful in improving the learning of mathematical concepts, including the important and fundamental concept of integral. Considering the importance of integral learning as one of the basic concepts of calculus and also considering the many problems that students

face in learning it, it seems that the use of artificial intelligence and especially ChatGPT and GPT-4 which is a It is a new and innovative method in education [44], it can help to increase the learning of the integral concept and reduce the obstacles to its learning [30, 33, 35]. Therefore, the purpose of this study is to investigate the use of ChatGPT and GPT-4 in integral learning by solving the problems of this concept among first year undergraduate students in mathematics. In addition, the benefits, opportunities, as well as disadvantages and challenges of using ChatGPT in integral education have been analyzed [25, 18].

2. Main Results

At the recall level, all three problems were given to ChatGPT. But the answers should be far from expectations. He was not very careful in writing mathematical symbols such as parentheses, brackets, etc., despite the lack of attention and precision to these symbols, mathematical operations, especially integral calculations, are associated with gross mistakes.

Understanding the second level of Bloom's classification was that three problems in this level were considered for teaching the concept of integral using artificial intelligence and especially ChatGPT [40]. The problems were formulated based on the themes of this level such as description, estimation and prediction [2, 4, 5, 7]. Algebraic description has been done to an acceptable extent, but geometrical description using figures and diagrams is not seen in it. He did the prediction and estimation just like the description algebraically. In addition, it has many shortcomings in estimating the answer for complex problems[10, 14, 16].

The application of integration rules in the algebraic solution of related problems was done completely and correctly by ChatGPT, and its ability to algebraically solve problems that required the application of integral rules seems desirable. On the contrary, ChatGPT was unable to use the integral in solving daily life problems such as the swimming pool problem and could not recognize that the integral can be used to solve this problem. In solving provable problems, he referred to sources from which the desired answer cannot be obtained. In general, ChatGPT has performed well at the application level only in using integral rules in solving simple algebraic problems [18, 28, 30]. Based on ChatGPT's answers to analysis level problems, it can be seen that ChatGPT has a great ability in analyzing and providing solutions to integral concept questions. Analyzing the function under the integral in order to determine its components in the method of part-by-part integration, comparing one function with another function, and also changing the right variable, which is a form of deconstruction of the primary function, was one of the things that ChatGPT handled very well [41, 19]. They were also successful in solving algebraic or symbolic questions. ChatGPT answered the issues related to the evaluation level better and more completely than GPT-4. Although drawing and using figures and diagrams were emphasized in all the problems related to this level of thinking, no figures or diagrams were presented either in the text of the answers or in the sources he provided.

The weakest performance of ChatGPT was seen in response to problems related to the level of creative thinking. Considering that creation is the highest level of Bloom's classification [6] and it was expected that artificial intelligence and especially ChatGPT could show its effectiveness in this stage, but the weakest performance was observed in this stage. He presented the use of the concept of integral in everyday life with a good example in algebraic mode, but it was not seen that he had creativity and an idea in presenting the quadruple integral and designed an extension of a specific type of integral. Even in response to the problem related to the generalization of the integral, he could not create an acceptable answer. It seems that ChatGPT has many problems in planning to generate new ideas based on previous information. Designing, building and planning are manifestations of thinking at the level of creation, which were not seen in the answers provided by this platform and even brought gross and confusing mistakes.

3. Summary of Proofs/Conclusions

This study showed that ChatGPT can be a useful teaching aid tool, but caution is necessary when using it, and guidelines for its optimal and complete use should be developed. According to the results obtained in this study, the main reason for the difficulties in ChatGPT with mathematics is its educational data. While exposed to a large amount of Internet text, the instructional data is not specifically designed for mathematical concepts and problem solving. As a result, ChatGPT may lack the mathematical knowledge and reasoning abilities necessary to handle complex mathematical problems. It seems that artificial intelligence can be a good guide for students in finding paths leading to solving problems and learning the concept of integral, and it can be considered a helpful tool for teachers, but it cannot be considered as a reliable and efficient method in education. This concept is fully considered. ChatGPT and GPT-4 cannot replace the teacher in the integral classroom, and it can even be said that its effectiveness is not greater than that of a teacher. It works better only in solving long algebraic problems that require a lot of calculations and also introducing and making resources available. There are fundamental flaws in these foundations that require the efforts of the founders to fix them. It is suggested that its graphic improvement should be paid attention to by the founders and programmers so that the drawing of the diagram and the drawing of the shape can be done in a complete and useful way. In generalizing the concept of integral at higher levels of thinking, it has not been effective and needs to be improved. In addition, it is suggested that the users of this platform try to present the content in the text of the answers and not refer to the sources too much, because it creates a kind of confusion for the users. It is also recommended to students and professors to use it in the classrooms because it performs calculations accurately and acceptably and provides good guidance for them. However, it should not be trusted by learners and users, because it has gross and sometimes simple mistakes that will cause misunderstandings and misunderstandings. It is suggested to the authors of the teaching resources related to the integral concept to compile the

resources in such a way that the capacity of artificial intelligence and especially ChatGPT can be used in integral education.

REFERENCES

- [1] S. M. Adeniji, P. Baker and M. Schmude, Structure of the Observed Learning Outcomes (SOLO) model: A mixed-method systematic review of research in mathematics education, *EURASIA Journal of Mathematics, Science and Technology Education*, **18** (2022).
- [2] L. W. Anderson and D. R. Krathwohl, *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*, Allyn and Bacon. Boston, MA (Pearson Education Group), 2001.
- [3] D. Baidoo-Anu and L. O. Ansah, Education in the era of generative artificial intelligence (AI): Understanding the potential benefits of ChatGPT in promoting teaching and learning, *Journal of AI*, **7** (2023) 52–62.
- [4] M. T. Chandio, N. Zafar and G. M. Solangi, Bloom's taxonomy: reforming pedagogy through assessment, *Journal of Education and Educational Development*, **8** (2021) 109–140.
- [5] A. H. Chillon, J. G. Molina, J. R. Hoyos and M. J. Ortín, Propagating Schema Changes to Code: An Approach Based on a Unified Data Model, *CEUR Workshop Proceedings*, 2023 pp. 10.
- [6] J. W. Creswell, Mapping the field of mixed methods research, *Journal of mixed methods research*, **3** (2009) 95–108.
- [7] E. Dubinsky, Using a theory of learning in college mathematics courses, *MSOR Connections*, **1** (2013) 10–15. <https://doi.org/10.11120/msor.2001.01020010>
- [8] X. Q. Dao and N. B. Le, Investigating the effectiveness of ChatGPT in mathematical reasoning and problem solving: evidence from the vietnamese national high school graduation examination, *arXiv preprint arXiv:2306.06331*, 2023.
- [9] R. Ely and S. R. Jones, The teaching and learning of definite integrals: a special issue guest editorial, *Int. J. Res. Undergrad. Math. Ed.*, **9** (2023) 1–7.
- [10] M. Forehand, Bloom's taxonomy, *Emerging perspectives on learning, teaching, and technology*, **41** (2010) 47–56.
- [11] S. Fowler, C. Cutting, S. H. Fiedler and S. N. Leonard, Design-based research in mathematics education: trends, challenges and potential, *Mathematics Education Research Journal*, **35** (2023) 635–658.
- [12] S. Frieder, L. Pinchetti, R. R. Griffiths, T. Salvatori, T. Lukasiewicz, P. C. Petersen and J. Berner, Mathematical capabilities of chatgpt, *arXiv preprint arXiv:2301.13867*, 2023.
- [13] A. S. González-Martín, The use of integrals in engineering programmes: A praxeological analysis of textbooks and teaching practices in strength of materials and electricity and magnetism courses, *Int. J. Res. Undergrad. Math. Ed.*, **7** (2021) 211–234. <https://doi.org/10.1007/s40753-021-00135-y>.
- [14] S. Grassini, Shaping the future of education: exploring the potential and consequences of AI and ChatGPT in educational settings, *Educ. Sci.*, **13** no. 7 (2023) 692.

- [15] N. Hashemi, H. Kashefi and M. S. Abu, The emphasis on generalization strategies in teaching integral: calculus lesson plans, *Sains Humanika*, **12** (2020) 35–43.
- [16] D. Horiuchi, H. Tatekawa, T. Oura, T. Shimono, S. L. Walston, H. Takita et al, Comparison of the diagnostic accuracy among GPT-4 based ChatGPT, GPT-4V based ChatGPT, and radiologists in musculoskeletal radiology, *medRxiv*, **12** (2023) 26 pp.
- [17] C. H. Huang, Engineering students' visual thinking of the concept of definite integral, *Global Journal of Engineering Education*, **15** (2013) 111–117.
- [18] N. Hrebin, S. Grabovska, R. Karkovska and A. Vovk, Applying benjamin Bloom's Taxonomy ideas in adult learning, *Journal of Education Culture and Society*, **11** (2020) 61–72.
- [19] Jahanipour, Ruhollah and Maqsoodi, Saeed. The history of infinitesimals and infinitesimals in differential and integral calculus, *Mathematical Culture and Thought* , **38**(2018), 77-121. [In Persian].
- [20] N. Karjanto, Mathematical modeling for sustainability: How can it promote sustainable learning in mathematics education?, *arXiv preprint arXiv:2307.13663*, 2023.
- [21] C. K. Lo, What is the impact of chatgpt on education? a rapid review of the literature. *Educ. Sci.*, **13** no. 4 (2023) 410. <https://doi.org/10.3390/educsci13040410>
- [22] N. Mahir, Conceptual and procedural performance of undergraduate students in integration, *Int. J. Math. Educ. Sci. Technol.*, **40** (2009) 201–211. <https://doi.org/10.1080/00207390802213591>.
- [23] M. Mason, The van Hiele levels of geometric understanding, *Coleccion Digital Eudoxus*, **1** (2009).
- [24] J. Mason, L. Burton and K. Stacey, *Thinking Mathematically*, (2th edition), Edinburgh: Pearson, 2010.
- [25] M. B. Miles, A. M. Huberman, and J. Saldana, *Qualitative data analysis: a method sourcebook*, (3rd ed.), Thousand Oaks, California: Sage Publications, Inc, 2019.
- [26] F. Nursyahidah and I. Albab, Investigating student difficulties on integral calculus based on critical thinking aspects, *Jurnal Riset Pendidikan Matematika*, **4** (2017) 211–218. <http://dx.doi.org/10.21831/jrpm.v4i2.15507>.
- [27] T. Pelton and L. F. Pelton, Adapting ChatGPT to Support Teacher Education in Mathematics, *In Society for Information Technology and Teacher Education International Conference*, Association for the Advancement of Computing in Education (AACE), (2023) 1662–1670.
- [28] N. Pinede, Thematic Analysis of Hyperlinks: A Taxonomic Approach, *Analyzing Websites*, (2023) 191–229.
- [29] D. Serhan, Students' Understanding of the Definite Integral Concept, *International Journal of Research in Education and Science*, **1** (2016) 84–88. <https://files.eric.ed.gov/fulltext/EJ1105099.pdf>
- [30] A. Shoufan, Exploring students' perceptions of ChatGPT: thematic analysis and follow-up survey, *IEEE Access*, **11** (2023) 38805–38818. <http://dx.doi.org/10.1109/ACCESS.2023.3268224>.
- [31] U. Sholihah and M. Maryono, Students' visual thinking ability in solving the integral problem, *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, **5** (2020) 175–186. <https://doi.org/10.23917/jramathedu.v5i2.10286>.
- [32] R. Sternberg, Applying psychological theories to educational practice, *American Educational Research Journal*, **45** (2008) 150–165.

- [33] O. Stumke, Information communication technology integration via Bloom's taxonomy in accountancy curriculum, *Transformation in Higher Education*, **8** (2023) 11 pp.
- [34] A. D. Sulistyaningtyas and R. R. Wantika, Analysis of student learning difficulties in solving calculus II course case studies, *Journal of Education and Learning Mathematics Research (JELMaR)*, **4** (2023) 171–178.
- [35] J. P. Remoto, ChatGPT and other AIs: Personal relief and limitations among mathematics-oriented learners, *Environment and Social Psychology*, **9** (2024) 13 pp. <https://doi.org/10.54517/esp.v9i1.1911>
- [36] D. Tall, Students' difficulties in calculus, *In Proceedings of Working Group*, **3** (1993) 13–28.
- [37] D. Tall, *Making sense of mathematical thinking over the long term: the framework of three worlds of mathematics and new developments*, Draft. To appear in D. Tall, and I. Witzke (Eds.): MINTUS: Beiträge zur mathematischen, naturwissenschaftlichen und technischen Bildung. Wiesbaden: Springer, 2019.
- [38] R. D. Thomas, James Hutton's concept of time: that of Leibniz, not Newton, *Geology Today*, **38** (2022) 108–111.
- [39] H. H. Thorp, ChatGPT is fun, but not an author. *Science*, **379** (2023) 313–313.
- [40] I. Umami, Moderating influence of curriculum, pedagogy, and assessment practices on learning outcomes in Indonesian secondary education, *Journal of Social Studies Education Research*, **9** (2018) 60–75. <https://jsser.org/index.php/jsser/article/view/243>.
- [41] K. V. Vlasenko, I. V. Lovianova, O. O. Chumak, I. V. Sitak and D. A. Kovalenko, The wheel of mathematics learning methods, *J. Phys.: Conf. Ser.*, **2611** (2023). <https://doi.org/10.1088/1742-6596/2611/1/012001>
- [42] Y. Wardat, M. A. Tashtoush, R. AlAli and A. M. Jarrah, ChatGPT: A revolutionary tool for teaching and learning mathematics, *Eurasia Journal of Mathematics, Science and Technology Education*, **19** (2023). <https://doi.org/10.29333/ejmste/13272>
- [43] R. P. Yudha, Higher order thinking skills (HOTS) test instrument: Validity and reliability analysis with the rasch model, *EduMa: Mathematics education learning and teaching*, **12** (2023) 21–38.
- [44] Z. Zafrullah, M. L. Hakim and M. Angga, ChatGPT open AI: Analysis of mathematics education students learning interest, *Journal of Technology Global*, **1** (2023) 1–10.
- [45] Z. Zetriuslita, R. Ariawan and H. Nufus, Students' critical thinking ability: Description based on academic level and gender, *Journal of Education and Practice*, **7** (2016) 154–164.

Nourooz Hashemi

Department of Mathematics Education, Farhangian University, P.O.Box 14665-889, Tehran, Iran
Email: h.nourooz@cfu.ac.ir

Hamidreza Kashefi

Department of Mathematics Education, Farhangian University, P.O.Box 14665-889, Tehran, Iran
Email: hkashefi@cfu.ac.ir