

ChatGPT—A Threat or an Aid in Teaching and Learning

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Abstract

The use of artificial intelligence (AI) in education can have a beneficial effect on learners' attitudes and self-assurance toward learning. However, it may also present a danger of substituting teachers and interpersonal interactions that are essential for learners' holistic development. This research investigated the use of AI, specifically the Chat Generative Pre-trained Transformer (ChatGPT), in education and whether it is an ally or a threat to teaching and learning. It discussed and elaborated how AI has changed the traditional practice, principles, culture, and theory in education. Moreover, it identified the advantages and disadvantages of using ChatGPT in education, potential paradigm shifts that may arise from its use, and its impact on science and mathematics education. Furthermore, this study presented an analysis of ChatGPT's responses to standardized marking schemes in science and mathematics and provided valuable insights into how AI can be integrated into the teaching and learning of science and mathematics. This study concluded that a review of the assessment approaches, as well as an open-minded perspective in adapting the curriculum and pedagogies with the incorporation of AI, are needed to maximize the learning outcomes of 21st century learners.

Keywords: *artificial intelligence, ChatGPT, teaching and learning, educational paradigm shift, question analysis*

Introduction

The influence of technology over education is something that can only be embraced rather than prevented. It plays a crucial role in teaching science which has the potential to either destroy or improve the educational experiences. This paper inquired whether ChatGPT (Generative Pre-trained Transformer) is an ally or a threat to teaching and learning. This is the question that this study aimed to answer.

Artificial intelligence (AI) and machine learning are integral components of Web 3.0, which is the promising concept of the next evolution in web technology (Margarette, 2022). Web 3.0 is a highly open, and free learning environment that has been modifying the practice, culture, and theory in the use of technology

and the internet (Gallardo-Echenique, 2015). The revolution in their learning behavior impacts their learning environment, with such, they can learn not only in the confines of a classroom but in any place where they have access to the internet. Equally, Web 3.0 as their learning environment also contributes to this change of behavior in such a way that they can create their own learning experience based on their preference and interest, by creating their websites or learning from multiple websites, reading, and watching videos, or by learning collaboratively through virtual interactions and video conferences. These behaviors can either reverse or reinforce the person. Thus, Bandura's theory on reciprocal determinism is a basis for understanding the learners of Web 3.0 (Jiang, 2014). This proposition supports that the learners' behavior towards learning is influenced by their interaction with AI, and in turn, the AI's adaptive behavior is influenced by the learner. To wit, Reciprocal determinism, based on Bandura's Social Learning theory, postulates that personalities can both influence and be influenced by behavior and the environment (Bandura, 1986). Hence, this research explores how AI, like ChatGPT, can serve as a conversational tutor, providing explanations and generating responses consistent with the topic being asked and discussed. Moreover, the students' change in behavior is seen in their improved self-confidence in the knowledge that they acquired through a positive reinforcement upon having obtained a quick response they receive from an AI. While instead of collaborating with humans, these learners interact with AI; they become teammates more than just a tool for learning (Seeber, I., et.al, 2020). Thus, the learners' self-confidence is heightened, which further increases their curiosity and interests to continue developing their learning and construct concrete knowledge. This process of constructing knowledge is supported with the Constructivism theory, where learners build their representations by reflecting upon their experiences with the new information and integrating it into their pre-existing knowledge (McLeod, 1970).

The idea that the learner develops a positive behavior towards learning using AI shows that AI can be an aid and has vantage in teaching and learning. On the other hand, the AI's interaction with humans develops the AI's abilities of providing information, therefore can be a threat in replacing human-to-human interaction in education.

Since the new generation of learners are digital natives, it is much easier for them to learn with technology, more so with AI, which students perceive as a way to answer their difficulties in learning (Seo, K., et.al, 2021). Therefore, technology has great influence on the educational experience and thus, this paper inquired whether ChatGPT can be used to greatly enhance the math and science education experience for students, specifically support and extend the work of teachers, which includes other effects circumstantial with the use of the tool.

To begin with, ChatGPT is a conversational tutor or a language processing tool available on the internet that can answer most questions, simple or complex. It can create content and images. It is built to have the ability to understand the context of a conversation and generate feedback and comments that are relevant to the topic being discussed. Moreover, it can provide explanations in

natural language, making it a valuable tool for students learning a new concept. Moreover, the teachers can use this tool to grade essays, give comments and feedback on student writing, or offer suggestions for improvement (Dickinson, 2023).

ChatGPT was framed to cover massive amounts of dataset source from both the internet and interactions, making it an adaptive and flexible AI (Montti, 2023; Hughes, 2023). Everybody can access this tool by visiting chat.openai.com and creating an account. Once signed in using either your email address or your website, one can get a conversation by asking a question or typing a question in an inbox. This time it is free to use because this tool is still in its research stage.

Hence, based on the preceding discussion, the researchers were driven to use a research-based and evidence-informed method to understand deeper the use of AI in teaching and learning. The study also aimed to identify potential educational issues and paradigm shifts that may arise from its use. Additionally, the research comprehensively analyzed AI's responses to conceptual questions in science and mathematics by comparing them with standardized marking schemes.

Objectives

The study sought to: (1) organize existing knowledge into a framework to understand the use of AI in teaching and learning; (2) Assess the generated responses provided by ChatGPT to the IB Organization's past paper questions in comparison with the IB Organization's mark scheme.

This research is a valuable resource for students and researchers seeking to expand their knowledge of artificial intelligence and the use of ChatGPT. It can also benefit curriculum planners by providing insights into how AI and related applications can be integrated into the teaching and learning of science and mathematics.

Review of Related Literature

This section illustrates the relevant literature and studies on the use of ChatGPT in education in general.

Advantages of Using AI for Teaching and Learning

The use of AI can be beneficial to the learners just like how technology is beneficial to humankind. This portion of the paper presents the advantages that the use of AI in education can offer.

With the use of AI, like ChatGPT, learning can be more customized and adaptive based on the student's intellectual capabilities, own pace, and interests. AI can detect if a student struggles with some tasks or concepts and offers additional tutoring by giving more background information on the topic (Khan, et.al., 2021). On the other hand, AI also detects students who can handle normal learning

tasks easily and additional assignments are offered. In this manner, students are calmer in their learning process, and this makes them progress faster (Seo, et.al, 2021). As learning with AI is adaptive to the capabilities of the learner, the student is challenged enough but not overwhelmed, which gets the learner to be more engaged rather than frustrated.

With ChatGPT, a response is generated quickly in just a span of less than a minute per question (Stein, 2023). With this, the students can get immediate feedback on their work allowing them to act accordingly. Learners can base their responses on the responses from ChatGPT which can help the learners correct their mistakes and improve their learning performance (Bridgeman, Liu, Miller, 2023).

The use of AI in education can be affordable and cost-effective. AI can be a teacher's assistant in administrative tasks such as marking papers, checking grammar and other typing tasks, thus giving some time for the teacher and some more time for personalized interactions with the students (Holmes, et.al., 2022). In the same manner, the time spent for the learners to understand a concept would be faster, as immediate feedback can be given by an AI, thus increasing the learner's confidence in the concept, and can move on to the next tasks that are of higher learning taxonomy (Kay, et.al., 2022).

Lastly, with the use of AI, learning can be accessed anytime, anywhere, which leads to greater access to education (Haleem, et.al., 2022). Through the use of Web 3.0, learning can be done even without having to pay tuition fees. There are multiple prestigious universities, even those in the Ivy League, that are now offering free access to learning, as well as the student has an access to the internet and the interest to learn (Lane, 2023).

Disadvantages of Using AI in Teaching and Learning

The use of AI in teaching and learning has several potential disadvantages, which should be carefully considered. One of the main concerns is the cost. While ChatGPT is currently free to use, once well-educated experts have spent years creating artificial intelligence, the cost of access may become substantial. According to Careerera (2021), research funding and compensation for project participants must be accounted for, and private companies often develop AI tools for profit, requiring consumers to pay for access. This can create a bias in providing AI resources for students who cannot afford them, limiting their access to the same level of education and opportunities as their financially advantaged peers.

Another potential disadvantage is that ChatGPT may reduce students' capacity for thought, specifically their ability to think critically. As noted by Careerera (2021), when students rely heavily on AI systems like ChatGPT, they become less inclined to think for themselves and may not develop the skills necessary to solve complex problems or engage in critical thinking. Additionally, although ChatGPT can provide general knowledge, it may be limited to generating responses to specific expert knowledge beyond what is generally available to the internet or the public. It may not provide detailed answers to questions that

require expertise, and it can only provide a general answer based on its training data.

Furthermore, while ChatGPT can enhance the education experience, it should not be considered a substitute for personal interaction. According to LiveTiles (2022), relying too much on AI to assess or teach may lead to educational lapses in providing adequate educational opportunities or support to students. This can occur at various levels, such as a lack of empathy and personalized feedback. Teachers need to build a positive relationship with the students to provide a rich and meaningful supportive environment. Personalized feedback based on students' strengths, weaknesses, and learning styles can be provided. Teachers can also give emotional support, encouragement, and inspiration, which can help students to maintain their interests and be engaged and motivated in their learning.

Moreover, the communication barrier between computers and humans is still significant (Singh, 2022). Humans communicate using context, not only words but also gestures, facial expressions, and the like, to convey meaning. While AI systems like ChatGPT can recognize and respond to certain contextual cues, they may still have difficulties fully understanding the complexity of human communication. Humans use language in creative and figurative ways, such as humor, poetry, and storytelling. AI systems may lack the capacity to emulate this level of ingenuity and may encounter difficulties comprehending or producing such language.

While the use of AI in teaching and learning has many potential benefits, it also has several potential disadvantages. It is essential to consider these disadvantages to ensure that the use of AI in education is well-informed and well-planned. Proper consideration and implementation can help maximize the benefits of AI in education while minimizing its potential drawbacks.

Educational Challenges Arising from the Use of AI in the Classroom

The application of artificial intelligence in general, and specifically in the field of education, poses serious risks that must be thoroughly investigated. Current generations appear to be more connected to their networks and technological tools, but also more disconnected from their neighbors, families, and even themselves. If we add to these empty classrooms, the absence of human teachers, and contact with robots, and other artificial intelligence instruments, what kind of individual are we forming for the support of the planet and future generations?

Currently, the challenges that pose a threat to quality education include upholding academic integrity and honesty, new access issues concerning subscription fees, increased issues on data privacy, and changes to job markets and skill sets (Elgersma, 2023).

Upholding academic integrity and honesty is the major challenge in education that the use of AI can pose. Students are handling AI-generated essays without proper acknowledgment of their sources. Also, generated responses

from ChatGPT come from a wide variety of sources for which creators are not credited, therefore are not academically ethical. As AI can learn from multiple sources, it can present biases to the correctness of the material (Eaton, 2023).

ChatGPT is currently free of use and also has a paid version. This divides the types of users into the more advantaged and those of the lesser edge, thereby not everyone has equal access to all the benefits that ChatGPT offers (Gates, 2023). Reuters, 2023, reported that ChatGPT is currently the fastest-growing user-based chatbot (Hu, 2023). For every sign-up, ChatGPT warns its users about its data collection and privacy of such, hence, the impact of AI on privacy can be an issue, since data is a hot commodity in this Web era (Eliot, 2023).

Indeed, the use of AI in education poses challenges that are currently shifting the educational paradigm, hence, UNESCO, 2019, has published a working paper that highlighted six main challenges that the education sector needs to address, namely, the lack of a comprehensive policy on AI for sustainable development, ensuring inclusion and equity in AI in education, preparing teachers for AI-empowered education and preparing AI to understand education, developing quality and inclusive data systems, making significant research on AI in education, and ethics and transparency in data collection, use and dissemination (Bin-Mahfooz, 2019).

With these, the main concern that is posed to the education system is the preparation of the students for a world with AI, in which job markets cannot yet quite be imagined, yet the education sector needs to prepare its students for it.

Methodology

The study utilized exploratory and analytical approaches. It delved into the cultural, theoretical, and practical changes brought about by ChatGPT in education, which allowed for an understanding of the nature and characteristics of AI in education and its implications for teaching and learning. A structured educational paradigm that encompasses the entire concept of AI across different aspects of education was developed based on the analysis of the existing literature regarding the advantages and disadvantages of ChatGPT in education and its impact on student learning. Furthermore, this study focused on the application of AI in the area of marking assessments by scrutinizing the responses generated by ChatGPT to standardized questions framed by the IB organization, providing researchers with information to draw their conclusions.

Exploratory Approach

Ways to Transform Educational-AI Challenges into an Opportunity

The use of ChatGPT in education presents both challenges and potential threats. While it has the potential to help improve teaching and learning experiences, there are also potential risks that need to be addressed. The researchers summarized the challenges alongside the opportunities to transform them into great potential.

Academic Integrity and honesty are among the few potential challenges associated with ChatGPT in education (Cullen, W. by C., 2023). This refers to the possibility of students using the technology to cheat and commit plagiarism on assignments, examinations, and other academic requirements (Cullen, W. by C., 2023). As AI-powered tools like ChatGPT can give automated responses that may not be their work, it could undermine the assessment processes that are vital to education. Therefore, it is important to implement a policy and a set of guidelines for the ethical use of ChatGPT in academic settings, more, with the proper and frequent re-orientation of the students on emphasizing academic integrity and honesty. Moreover, developing plagiarism detection tools like Turnitin can also help identify rule breakers. In addition, giving assessments that involve creating diagrams and illustrations would foster creativity among learners while they apply their knowledge whether such are taken from written scripts or ChatGPT, as this AI is not capable of creating one as shown in Figure 1.

Figure 1

ChatGPT's answer on creating a diagram of the Calvin cycle



Create a diagram of the Calvin cycle and the enzymes involved in it.



I'm sorry, as an AI language model, I am not able to create visual diagrams. However, I can describe the Calvin cycle and the enzymes involved in it.

The Calvin cycle, also known as the C₃ cycle, is a set of reactions that takes place in the chloroplasts of photosynthetic organisms such as plants, algae, and cyanobacteria. The cycle is named after its discoverer, Melvin Calvin.

The Calvin cycle is a complex set of chemical reactions that converts carbon dioxide into organic compounds, specifically glucose. The cycle consists of three phases: carbon fixation, reduction, and regeneration.

During the carbon fixation phase, an enzyme called rubisco combines carbon dioxide with a five-carbon sugar called ribulose bisphosphate (RuBP) to form a six-carbon compound that quickly breaks down into two molecules of 3-phosphoglycerate (3-PGA).

During the reduction phase, ATP and NADPH produced by the light-dependent reactions of photosynthesis are used to convert the 3-PGA into a three-carbon sugar called glyceraldehyde 3-phosphate (G3P). This step requires a series of enzymes, including glyceraldehyde 3-phosphate dehydrogenase (GAPDH) and phosphoglycerate kinase (PGK).

Finally, during the regeneration phase, some of the G3P is used to regenerate RuBP, while the rest is used to produce glucose and other organic compounds. This phase requires a number of enzymes, including triose phosphate isomerase (TPI), transketolase, and transaldolase.

Overall, the Calvin cycle is a highly regulated process that is essential for the production of glucose and other organic compounds in photosynthetic organisms.

Ensuring equitable access to AI-empowered education is also a potential challenge that may arise with the use of ChatGPT. This refers to equal opportunities for all students to benefit from the use of AI in education, regardless of geographic location, special socio-economic status, and/or other factors that could otherwise create hindrances to accessing ChatGPT which also includes high-speed internet connectivity and appropriate training, and support to use these tools effectively. Educational entities can also subscribe to a business profile that each of the learners in that institute can use. This can be taken from the “computer fees” that are collected from the students. For less privileged schools, lobbying for assistance from philanthropists can be an option (Fensterwald, 2023).

Another key challenge that must be considered in the use of ChatGPT in education is the issue of data privacy. Given that this technology requires the processing of large amounts of data, including the personal information of the students and teachers, there is also a significant risk of unauthorized access to sensitive data. As a result, an action plan for the use of AI must be put in place and be a government's obligatory requirement for every educational sector. A worldwide policy that involves the end-users, as well as the AI-producing sectors, must also be created (OECD, 2019). Moreover, educational institutions should take steps to protect the privacy of students and teachers, and make sure that everyone is informed about how their personal information is being used. Institutions need to keep personal data safe and use it responsibly and ethically. Otherwise, it could lead to breaches of privacy and damage the institution's reputation.

The need to prepare both teachers and AI for this new paradigm of education is another one of the challenges in the use of ChatGPT in education. This involves providing teachers with the necessary training and skills to effectively use and adapt AI tools into their teaching practice, as well as assisting them to understand how AI can improve the learning experience for their students. More, being actively involved in studies about AI, either being a participant or a researcher. In this way, both the teacher and the AI can learn from each other. Teachers are the deliverers and facilitators of knowledge, hence if AI can learn, then the best to teach AI is an educator, thus humanizing the chatbots (Tilili, et.al., 2023).

Could the Use of AI Create a Shift in the Educational Paradigm?

There has been considerable attention given to the use of ChatGPT in education with many schools around the world having already embraced the use of ChatGPT in their curriculum (Myklebust, 2023). As a matter of fact, the International Baccalaureate Organization (IB) has declared its approval of the use of ChatGPT, as long as its use in papers must uphold academic integrity (Glanville, 2023).

The use of ChatGPT in education is gaining popularity as more schools and universities are incorporating this AI-powered tool into their teaching and learning practices. With the fact that in March 2023, IB has over 5600 affiliated schools in 159 countries worldwide, it can be assumed that ChatGPT is accepted in schools around the world (IBorganization, n.d.). Additionally, top international universities, such as Cambridge University and Oxford University have also expressed their approval of the use of AI in education, for as long as such would not be used for writing exams and other assessed work (Stephens, 2023). This demonstrates that the potential benefits of using ChatGPT in education are recognized by leading educational institutions.

Aside from these organizations, different countries have embraced ChatGPT in their educational system. Vietnam has joined Asia's rush to accept ChatGPT even though the Microsoft-backed AI bot has yet to launch in the country. While some of the biggest organizations in the nation are exploring the potential of a technology that composes emails, essays, code, and even news stories based

on simple user cues, the excitement has given rise to a cottage industry offering accounts that are intended to be free. In Vietnam, dozens of Facebook groups devoted to OpenAI's platform have sprouted up, with one boasting 79,000 members and is far from alone in Asia in its embrace of ChatGPT.

Adopting AI in education brings up new possibilities, difficulties, and opportunities for educational practices, and therefore a shift in the educational paradigm. Ouyang, et.al., 2021 presented three educational paradigms that described the development of AI use in education. At first, it was AI-directed learning where the learner acts as a recipient. This paradigm was based on the learning theory of behaviorism, where carefully arranged sequences of concepts from the AI can lead to the learner's correct performance. The main issue in this paradigm is the inadequate adaptability of the AI to the learner, hence may result in insufficient guidance in knowledge development and skills acquisition. Examples of platforms that use this paradigm are online technology-based tutoring systems like Khan Academy and the like, higher level online calculators like desmos, or chemical formula generators. The second paradigm proposed in that same study was AI-supported, where the learner served as a collaborator, and the AI only acted as a support. This AI-supported paradigm was based on the theory of constructivism, where learning happens from the learner's social interaction with people, information, and technology. The online labs or simulations are examples. The lack of continuous communication or synergetic human-computer interactions was the issue in this paradigm. Immediate feedback on the learner's progress is not considered by the AI. Lastly, AI-empowered learning as a paradigm was deemed more precise, where the learner served as a leader in the learning process. Constructivism, together with the perspective that education is a complex adaptive system, are the theories that govern this paradigm. The learner has total control over the extent of use of the AI based on his needs and interests (Ouyang et al.,2021). To this date, the most recent AI that uses Paradigm 3 is ChatGPT and its soon-to-be-launched version, GPT-4 (Hughes, 2023).With this AI-empowered chatbot, a paradigm shift in the current methods of instruction and delivery is at hand. ChatGPT/GPT-4 is creating reform in education (Zaveria, 2023).

Emerging Research Framework

From these perspectives, the researchers of this study presented the AI-empowered framework. It shows that the shift in the educational paradigm should now include the incorporation of artificial intelligence that overlaps with the realms of pedagogy, the teacher, and the curriculum, yet maintaining the learner as the center of learning.

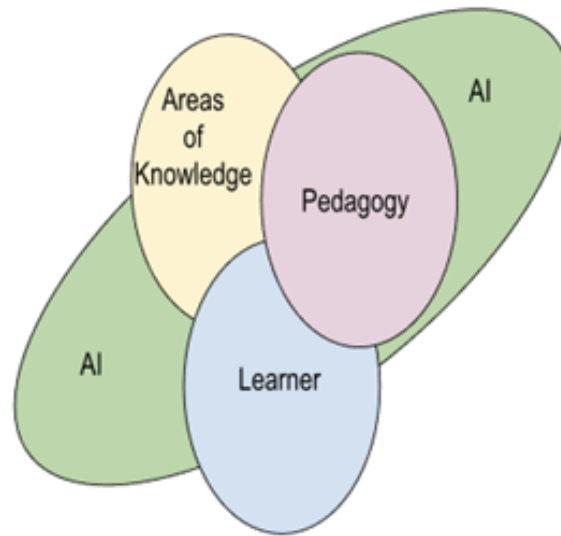
Figure 2*AI-empowered Educational Framework*

Figure 2 shows an educational framework where the use of AI is incorporated into the aspects of education. The AI, in this case, ChatGPT, should be carefully intertwined with the areas of knowledge, the teaching strategies and methods, and the learner. The education system should upskill itself concerning the competencies and practices that can meet the demands of the new technology. Moreover, ChatGPT fosters new ways of thinking and schematic construction of knowledge, where teachers need to reform the learning environment to cultivate the learner's ways of assembling their knowledge. Embracing technology rather than banning it will prepare learners for the future job market that is yet to show itself (Tilili, et.al., 2023). In the framework shown above, it can be seen that pedagogy is fully engulfed inside AI. This means that the teacher must incorporate the use of technology and chatbots in the classroom, yet with the teacher's constant guidance and facilitation in the learning environment. On the other hand, the areas of knowledge are only halfway enveloped by AI. Written scripts are a more reliable source of information and should not be replaced wholly by AI (Chow & Perrigo, 2023). In the same manner, though the learners of today are digital natives, AI must only be a learning tool rather than the basis of knowledge, since human interaction and direct experience with knowledge in real life are more effective methods of developing a holistic learner (Singh, 2022).

Analytic Approach

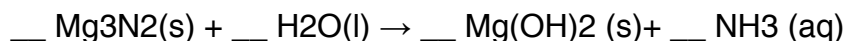
Analyzing Sample Answers from ChatGPT in Comparison to a Given Mark Scheme from the IB Organization

To test the reliability and extent of the "intellectual" capabilities of ChatGPT, sample questions from IB's past paper higher level questions from the three sciences, Chemistry, Biology, and Physics, and Math, were asked in ChatGPT. Two sample questions in each science subject were selected in a manner that involved answers in short-essay and calculations, which were furthermore,

categorized based on Bloom's taxonomy. ChatGPT's answers were compared with the markscheme from IB and given a score by the marks allotted for each question. The markings were done by tenured subject teachers of IB.

Firstly, Figure 3 presents a chemistry question that demands merely to balance a chemical equation:

The presence of magnesium nitride can be demonstrated by adding water to the product. It is hydrolyzed to form magnesium hydroxide and ammonia. Calculate coefficients that balance the equation for the following reaction.



The generated answer of ChatGPT is correct, based on IB organization's mark scheme, as shown in Figure 4. In addition, it clearly enumerated the steps carried out to come up with the answer. ChatGPT is proficient in answering this type of question which is categorized in Bloom's taxonomy as understanding as well as applying.

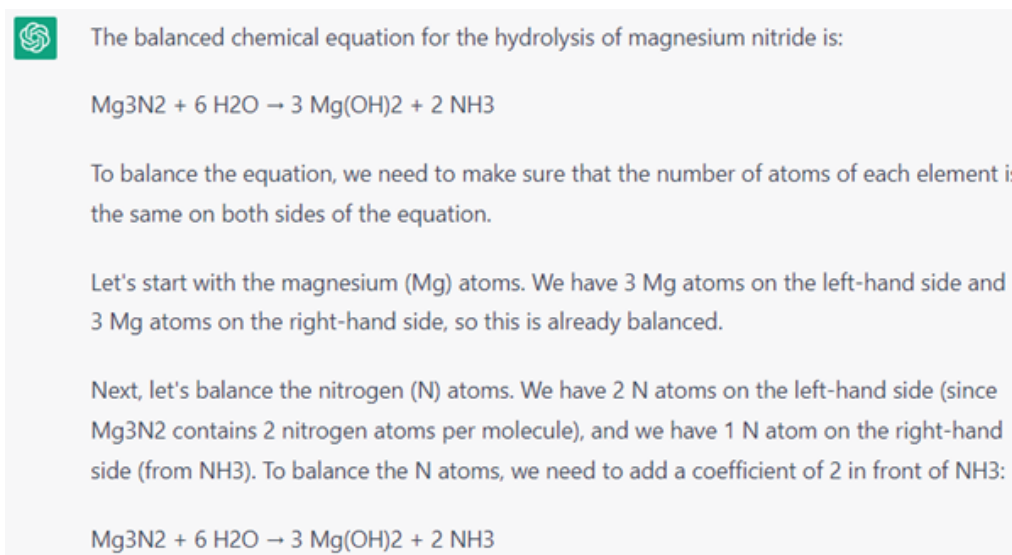
Figure 3

IB Organization's answer on Chemistry Question 1

«1» $\text{Mg}_3\text{N}_2(\text{s}) + 6 \text{H}_2\text{O}(\text{l}) \rightarrow 3 \text{Mg}(\text{OH})_2(\text{s}) + 2 \text{NH}_3(\text{aq})$ ✓	1
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Figure 4

ChatGPT's answer for Chemistry Question 1



The balanced chemical equation for the hydrolysis of magnesium nitride is:

$$\text{Mg}_3\text{N}_2 + 6 \text{H}_2\text{O} \rightarrow 3 \text{Mg}(\text{OH})_2 + 2 \text{NH}_3$$

To balance the equation, we need to make sure that the number of atoms of each element is the same on both sides of the equation.

Let's start with the magnesium (Mg) atoms. We have 3 Mg atoms on the left-hand side and 3 Mg atoms on the right-hand side, so this is already balanced.

Next, let's balance the nitrogen (N) atoms. We have 2 N atoms on the left-hand side (since Mg_3N_2 contains 2 nitrogen atoms per molecule), and we have 1 N atom on the right-hand side (from NH_3). To balance the N atoms, we need to add a coefficient of 2 in front of NH_3 :

$$\text{Mg}_3\text{N}_2 + 6 \text{H}_2\text{O} \rightarrow 3 \text{Mg}(\text{OH})_2 + 2 \text{NH}_3$$

Now, let's balance the hydrogen (H) atoms. We have 12 H atoms on the right-hand side (6 from H₂O and 6 from Mg(OH)₂), so we need to add a coefficient of 6 in front of H₂O:



Finally, let's check if the equation is balanced by counting the atoms of each element:

On the left-hand side, we have: 3 Mg, 2 N, 12 H, and 6 O (from H₂O).

On the right-hand side, we have: 3 Mg, 2 N, 12 H, and 2 O (from Mg(OH)₂).

Therefore, the equation is balanced with the coefficients:



The next chemistry question solicits a rationalized identification of the type of chemical reaction that is exhibited in the given scenario:

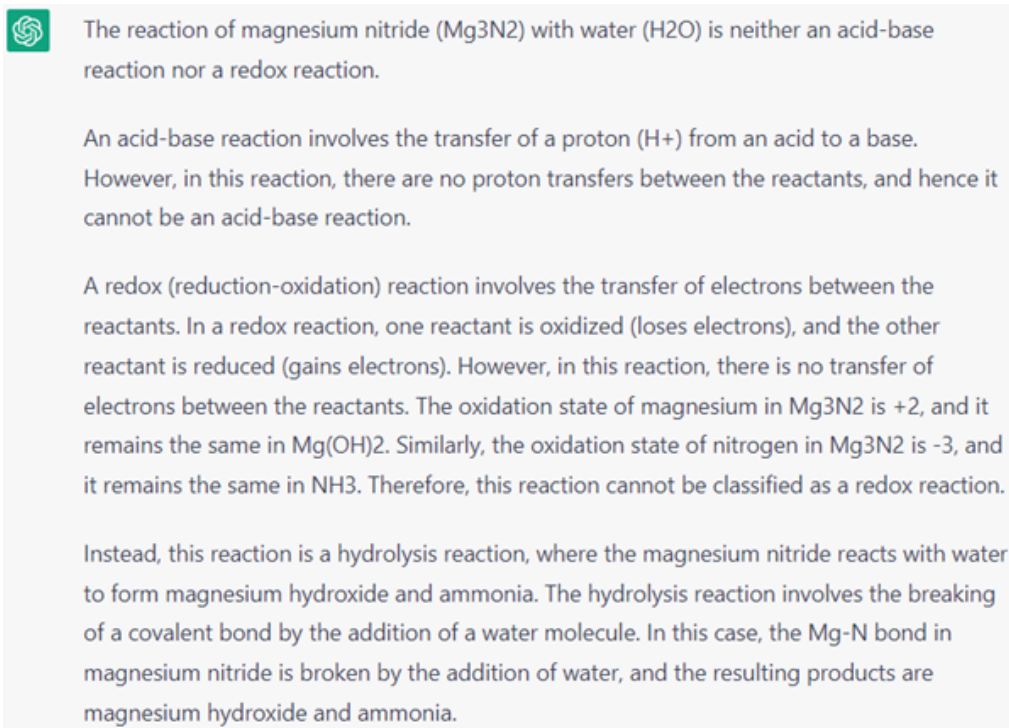
Deduce, giving reasons, whether the reaction of magnesium nitride with water is an acid-base reaction, a redox reaction, neither, or both.

The expected answer based on the mark scheme is a simple identification of the type of chemical reaction, that it is an acid-base reaction, together with a description of the transfer of cations and anions. The generated response of ChatGPT indicated that it is not an acid-base reaction nor a redox reaction, though it has correctly discussed these two chemical reactions, yet it rationalized hydrolysis as its answer. Its answer is somehow correct but is not on point. Should it be a biology question, it may have garnered a point yet still not a full mark. With this, it can be said that ChatGPT may be proficient in the lower categories of Chemistry questions based on Bloom's Taxonomy, but when it comes to analysis, it still needs to improve.

Figure 5

IB Organization's answer on Chemistry Question 2

<p>Acid-base: yes AND N³⁻ accepts H⁺/donates electron pair«s» OR yes AND H₂O loses H⁺ «to form OH⁻»/accepts electron pair«s» ✓</p> <p>Redox: no AND no oxidation states change ✓</p>	<p>Accept "yes AND proton transfer takes place"</p> <p>Accept reference to the oxidation state of specific elements not changing. Accept "not redox as no electrons gained/lost".</p> <p>Award [1 max] for Acid-base: yes AND Redox: no, if no other mark is awarded."</p>	2
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Figure 6*ChatGPT's answer on Chemistry Question 2*

Secondly, Biology questions were also asked. The first Biology question is about speciation as a result of the processes of isolation and selection. The answer generated by ChatGPT was partially correct, garnering 5 marks out of 7, based on the mark scheme provided by IB organization. Five out of the 13 concepts presented in the marks scheme were not described by ChatGPT, despite its lengthy explanations. The next Biology question is about the electron transport chain in cellular respiration. ChatGPT has extensively answered this question correctly garnering a mark of 7/7. Respectively, these questions were categorized in Bloom's Taxonomy under understanding and analyzing. With regards to Biology, ChatGPT's response shows partial accuracy but it necessitates expanding beyond explicit inquiry as the question demands the application of critical thinking.

Thirdly, the proficiency of ChatGPT in responding to understanding and analysis questions related to Physics subject is demonstrated in its generated answers. The first Physics question is about the application of Newton's laws on the given case. ChatGPT's answer was concise and brief. A style that is best to apply during the time-constrained IB exams. Moreover, the second Physics question is about acceleration that requires calculation. ChatGPT was able to answer this succinctly.

Lastly, Math questions were also asked. Both questions asked were in the category of analyzing and applying in Bloom's Taxonomy, which require calculations. ChatGPT's answers were incorrect for both, despite its lengthy explanation. ChatGPT's answers, as well as its working solutions do not match with the IB mark scheme.

In summary, ChatGPT demonstrates proficiency in some science related questions, where its answers can sometimes be correct or partially correct. In terms of math questions, ChatGPT consistently diverged from expected answers outlined in the mark scheme, which can be seen as a limitation of the chatbot. Table 1 below shows a summary of this.

Table 1

Categorization of questions and ChatGPT answers.

Subject Area	Question No.	Answer	Bloom's Taxonomy Categorization	Chat-GPT's Score	Comments
Chemistry	1	Figure 4	Understanding/ Applying	1/1	The answer from ChatGPT is more than what is asked for, as it has explained the step-by-step process of coming up with the correct answer.
	2	Figure 6	Analyzing	0/2	Though ChatGPT has correctly explained the concepts encompassed in the question, it did not give the correct answer.
Biology	1	Appendix B	Understanding	5/7	Comparing the answers from both sources, it can be distinguished that the mark scheme letters a, b, k, l, & m were not discussed in the answers of ChatGPT, hence the score of 5/7.
	2	Appendix D	Analyzing	7/7	Most of the statements were clearly described with more details than required.
Physics	1	Appendix F	Analyzing	3/3	ChatGPT has stated all three statements needed for a full mark, as stipulated in the mark-scheme of IB.

Subject Area	Question No.	Answer	Bloom's Taxonomy Categorization	Chat-GPT's Score	Comments
	2	Appendix H	Applying	2/2	The answer given by ChatGPT is extensively explained, where the principle behind the question, as well as the step-by-step process to arrive at the correct answer was made.
Math	1	Appendix J	Understanding/ Applying	1/2	Math is an exact science; therefore, numerical answers must be exact for both answers. A mark of 1 out of 2 was given for the correct explanation of the process.
	2	Appendix L	Analyzing	0/2	The final answers, as well as the working solution, do not match.

Conclusion

In conclusion, integrating ChatGPT into teaching practices and education offers significant advantages in enhancing students' learning experiences and improving their confidence. However, it is essential to recognize that excessive reliance on AI may risk undermining the crucial teacher-student interaction and relationship, which is essential for holistic student development. Reassessing the use and functionality of AI in education has revealed both its flaws and benefits. While there is ample proof of its potential to transform traditional practices for the better, concerns regarding its negative impact must not be overlooked. By identifying ways to transform challenges into opportunities, teachers can leverage AI to improve teaching and learning outcomes.

Furthermore, examining ChatGPT's performance in subjects like mathematics and science provides insights into its effectiveness in meeting educational standards. This suggests the need to reconsider assessment methods and adapt instructional content with AI assistance. Thus, integrating AI into education, while offering positive effects on learning, requires careful consideration of its advantages and disadvantages. Policymakers, educators, and experts must collaborate to ensure that students are well-prepared to thrive as 21st-century learners.

Recommendations

Based on the comprehensive analysis of the integration of ChatGPT, several recommendations can be implemented to enhance its benefits while lessening the potential risks and issues associated with its use.

Everyone must embrace AI as a supporting tool rather than a replacement for traditional teaching methods. Introducing ChatGPT into the classroom can indeed enhance learning experiences, providing instant feedback, and stimulating critical thinking. However, it must be used in moderation. It is crucial to maintain a balance between AI-driven instruction and human interactions. Educators and teachers remain the most important people in guiding students in their learning endeavors, facilitating meaningful discussions, and collaborating on activities that promote social, cognitive, and emotional development. By integrating AI as a tool within their pedagogical practices, they can create much more dynamic, responsive, and engaging learning environments that cater to diverse learners' interests and needs. While collaboration among stakeholders is essential for advancing AI-driven educational practices and maximizing learning outcomes, this suggests promoting interdisciplinary partnerships between educators, researchers, technology, and industry experts to cooperate with each other for innovative and relevant solutions that address emerging controversies, challenges, and opportunities in education. When they share their best methods and ideas, they can make the most of AI to help diverse students in a changing digital and technological world. This also ensures that AI is used well and keeps getting better. This way, students can do well in school and beyond, even as technology becomes more important. Moreover, stakeholders in education, such as policymakers, administrators, officials, and curriculum developers, also need to emphasize ethical considerations to ensure responsible AI implementation. This involves addressing concerns related to data privacy, algorithmic bias, and digital literacy. Educators should receive intensive training, workshops, and support to effectively integrate AI tools into their teaching practices while considering ethical usage among students. Additionally, curriculum frameworks and provisions should be modified or revised to include digital citizenship, policies, and AI literacy as essential components of 21st-century education. By fostering a culture of responsible AI usage from an early age, schools can empower students to navigate and handle the complexities of the digital world with confidence and integrity.

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Appendices

Appendix A

IB Organization's answer on Biology assessment question 1: Explain how speciation occurs, including the different processes of isolation and selection

<p>a. Species is a group of organisms that interbreeds (normally in the wild) and produce fertile offspring; b. within an interbreeding population there is variety / variation exists; c. some adaptations favour survival to reproductive age /survival of the fittest / natural selection; d. alleles for these adaptations become more frequent/are inherited in the population /change with time; e. speciation is the formation of new species; f. (speciation) occurs because populations have become reproductively isolated / no longer able to interbreed / exposed to different selection pressures; g. behavioural isolation involves differences in courtship or mating behaviours; h. temporal isolation involves differences in the timing of courtship or mating behaviours; i. geographical isolation / allopatric refers to the physical barriers that exist that keep two populations from mating; j. polyploidy can lead to reproductive isolation; k. stabilizing selection is when the two extremes of a trait have lower reproductive fitness (OWTTE) / favours average phenotype; l. directional selection is when one extreme of the trait has lower reproductive fitness (OWTTE); m. disruptive/diversifying selection favours both extreme phenotypes / intermediate phenotype has lower fitness;</p>	<p>OWTTE</p>	<p>7 max</p>
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Appendix B

ChatGPT's answer on Biology assessment question 1: Explain how speciation occurs, including the different processes of isolation and selection



Speciation is the process by which new species arise from existing ones.

This occurs through a combination of different processes, including isolation and selection.

Isolation is the process by which populations become separated and no longer interbreed. There are several types of isolation, including:

1. Geographic isolation: This occurs when physical barriers such as mountains, rivers, or oceans separate populations, preventing gene flow between them.
2. Reproductive isolation: This occurs when biological barriers prevent interbreeding between populations. This can be due to differences in mating behaviors, physical characteristics, or reproductive systems.

Selection is the process by which certain traits become more or less common in a population over time. This occurs through natural selection, sexual selection, and artificial selection.

1. Natural selection: This occurs when certain traits are advantageous in a given environment, allowing individuals with those traits to survive and reproduce more successfully than others.
2. Sexual selection: This occurs when certain traits are more attractive to potential mates, leading to increased reproductive success for individuals with those traits.
3. Artificial selection: This occurs when humans intentionally select certain traits in domesticated plants and animals, leading to the development of new varieties and breeds.

Over time, isolation and selection can lead to the accumulation of genetic differences between populations, eventually resulting in the formation of new species. This process can take thousands or even millions of years and is influenced by many factors, including environmental changes, genetic drift, and gene flow.


Appendix C

IB Organization's answer on Biology assessment question 2: Explain the role of the electron transport chain in the generation of ATP by cell respiration.

<p>a. electron transport chain performs chemiosmosis / chemiosmosis generates ATP; b. receives energy/electrons from oxidation reactions/from Krebs cycle/glycolysis; c. receives electrons from reduced NAD/NADH/reduced FAD/FADH; d. energy released as electrons pass from carrier to carrier (in the chain); e. release of energy (from electron flow) coupled to proton pumping; f. protons pumped into intermembrane space; g. creates proton gradient; h. protons diffuse back/move down the concentration gradient (across membrane); i. protons pass through ATP synthase; j. protons return to the matrix; k. flow of protons provides energy for generating ATP; l. electrons transferred to oxygen at end of electron transport chain;</p>		<p>7 max</p>
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Appendix D

ChatGPT's answer on Biology assessment question 2: Explain the role of the electron transport chain in the generation of ATP by cell respiration.



The electron transport chain (ETC) plays a crucial role in the generation of ATP by cellular respiration. It is a series of protein complexes and electron carriers located in the inner mitochondrial membrane in eukaryotes or the plasma membrane in prokaryotes.

During cellular respiration, glucose is broken down into pyruvate in the cytoplasm through glycolysis. Pyruvate is then transported into the mitochondria where it is converted into acetyl CoA through the process of the Krebs cycle. The high-energy electrons produced from these reactions are then carried by NADH and FADH₂ to the ETC.

The ETC consists of four protein complexes (complexes I-IV) and two electron carriers (ubiquinone and cytochrome c) that are arranged in order of increasing electronegativity. As electrons are passed along the chain, energy is released and used to pump protons (H⁺) from the mitochondrial matrix to the intermembrane space, creating a proton gradient.

This proton gradient is then used by ATP synthase to produce ATP through the process of oxidative phosphorylation. ATP synthase is a complex enzyme that uses the energy from the proton gradient to add a phosphate group to ADP, forming ATP.

Overall, the ETC plays a crucial role in generating ATP by cellular respiration by using the high-energy electrons from the breakdown of glucose to create a proton gradient, which is then used by ATP synthase to produce ATP.

Appendix E

IB Organization's answer on Physics assessment question 1: Airboats are used for transport across a river. To move the boat forward, the air is propelled from the back of the boat by a fan blade. An airboat has a fan blade of a radius of 1.8m. This fan can propel air with a maximum speed relative to the boat of 20ms⁻¹. The density of air is 1.2kg/m³. Outline why a force acts on the airboat due to the fan blade.

<p>ALTERNATIVE 1 there is a force «by the fan» on the air / air is accelerated «to the rear» ✓ by Newton 3 ✓ there is an «equal and» opposite force on the boat ✓</p> <p>ALTERNATIVE 2 air gains momentum «backward» ✓ by conservation of momentum / force is rate of change in momentum ✓ boat gains momentum in the opposite direction ✓</p>	<p>Accept a reference to Newton's third law, e.g. N³, or any correct statement of it for MP2 in ALT 1.</p> <p>Allow any reasonable choice of object where the force of the air is acting on, e.g., fan or blades.</p>	<p>3</p>
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Appendix F

ChatGPT's answer on Physics assessment question 1: Airboats are used for transport across a river. To move the boat forward, the air is propelled from the back of the boat by a fan blade. An airboat has a fan blade of a radius of 1.8m. This fan can propel air with a maximum speed relative to the boat of 20ms⁻¹. The density of air is 1.2kg/m³. Outline why a force acts on the airboat due to the fan blade.



When the air is propelled by the fan blade, it is pushed backward in the opposite direction to the desired motion of the boat. According to Newton's third law, for every action, there is an equal and opposite reaction. Therefore, as the air is pushed backward, it exerts a forward force on the fan blade and the airboat. This forward force is what propels the airboat forward. In other words, the fan blade generates a force by accelerating the air backward, which in turn generates an equal and opposite force on the boat, propelling it forward.

Appendix G

IB Organization's answer on Physics assessment question 2: In a test, the airboat is tied to the river bank with a rope normal to the bank. The fan propels the air at its maximum speed. There is no wind. Show that a mass of about 240 kg of air moves through the fan every second.

πR^2 OR «mass of air through system per unit time $\Rightarrow Av\rho$ seen ✓ 244 «kg s ⁻¹ » ✓	Accept use of Energy of air per second $= 0.5 \rho Av^3 = 0.5 mv^3$ for MP1.	2
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Appendix H

ChatGPT's answer on Physics assessment question 2: In a test, the airboat is tied to the river bank with a rope normal to the bank. The fan propels the air at its maximum speed. There is no wind. Show that a mass of about 240 kg of air moves through the fan every second.



We can use the principle of conservation of mass to calculate the mass of air that moves through the fan every second. The mass of air entering the fan must be equal to the mass of air leaving the fan.

Let's assume that the airboat is at rest and the fan is turned on. The fan propels the air with a maximum speed relative to the boat of 20 m/s. Therefore, the air enters the fan at 20 m/s. The area of the fan blade is $A = \pi r^2 = \pi(1.8 \text{ m})^2 \approx 10.18 \text{ m}^2$.

The volume of air passing through the fan every second is given by the formula:

$$\text{Volume} = \text{Area} \times \text{Speed}$$

$$\text{Volume} = 10.18 \text{ m}^2 \times 20 \text{ m/s} = 203.6 \text{ m}^3/\text{s}$$

The density of air is $\rho = 1.2 \text{ kg/m}^3$. Therefore, the mass of air passing through the fan every second is:

$$\text{Mass} = \text{Density} \times \text{Volume}$$

$$\text{Mass} = 1.2 \text{ kg/m}^3 \times 203.6 \text{ m}^3/\text{s} \approx 244.3 \text{ kg/s}$$

Therefore, the mass of air moving through the fan every second is about 240 kg (rounded to the nearest 10 kg), as calculated above.

Appendix I

IB Organization's answer on Math assessment question 1: It is known that the weights of male Persian cats are normally distributed with a mean of 6.1kg and a variance of 0.5^2 kg^2 . Find the proportion of male Persian cats weighing between 5.5kg and 6.5kg.

$$X \sim N(6.1, 0.5^2)$$

$$P(5.5 < X < 6.5) \text{ OR labelled sketch of region}$$

$$= 0.673 \text{ (0.673074...)}$$

(M1)

A1

[2 marks]

Appendix J

ChatGPT's answer on Math assessment question 1: It is known that the weights of male Persian cats are normally distributed with a mean of 6.1kg and a variance of 0.5^2 kg^2 . Find the proportion of male Persian cats weighing between 5.5kg and 6.5kg.



We can solve this problem by standardizing the weights of male Persian cats using the standard normal distribution, which has a mean of 0 and a variance of 1. To do this, we use the following formula:

$$z = (x - \mu) / \sigma$$

where z is the standardized score, x is the weight of the cat, μ is the mean weight, and σ is the standard deviation.

We want to find the proportion of male Persian cats weighing between 5.5kg and 6.5kg, so we need to standardize these weights:

$$z_1 = (5.5 - 6.1) / 0.5 = -1.2$$

$$z_2 = (6.5 - 6.1) / 0.5 = 0.8$$

Now, we can use a standard normal distribution table or calculator to find the area under the curve between these two standardized scores:

$$P(-1.2 < z < 0.8) \approx 0.7838 - 0.1151 \approx 0.6687$$

Therefore, approximately 66.87% of male Persian cats weigh between 5.5kg and 6.5kg.

Appendix K

IB Organization's answer on Math assessment question 2: In a small village there are two doctors' clinics, one owned by Doctor Black and the other owned by Doctor Green. It was noted after each year that 3.5% of Doctor Black's patients moved to Doctor Green's clinic and 5% of Doctor Green's patients moved to Doctor Black's clinic. All additional losses and gains of patients by the clinics may be ignored. At the start of a particular year, it was noted that Doctor Black had 2100 patients on their register, compared to Doctor Green's 3500 patients. Find a prediction for the ratio of the number of patients Doctor Black will have, compared to Doctor Green, after two years.

<p>(b) $\begin{pmatrix} 0.965 & 0.05 \\ 0.035 & 0.95 \end{pmatrix}^2 \begin{pmatrix} 2100 \\ 3500 \end{pmatrix}$</p> <p style="text-align: right;">(M1)</p> <p>$= \begin{pmatrix} 2294 \\ 3306 \end{pmatrix}$</p> <p>so ratio is 2294 : 3306 (=1147 : 1653, 0.693889...)</p>	<p>A1</p> <p>[2 marks]</p>
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Appendix L

ChatGPT's answer on Math assessment question 2: In a small village there are two doctors' clinics, one owned by Doctor Black and the other owned by Doctor Green. It was noted after each year that 3.5% of Doctor Black's patients moved to Doctor Green's clinic and 5% of Doctor Green's patients moved to Doctor Black's clinic. All additional losses and gains of patients by the clinics may be ignored. At the start of a particular year, it was noted that Doctor Black had 2100 patients on their register, compared to Doctor Green's 3500 patients. Find a prediction for the ratio of the number of patients Doctor Black will have, compared to Doctor Green, after two years.



We can solve this problem by using a system of linear equations to model the flow of patients between the two clinics over two years.

Let x be the number of patients on Doctor Black's register after two years, and let y be the number of patients on Doctor Green's register after two years. Then, we have:

$$\begin{aligned}x &= 0.965(2100) + 0.05(3500 - y) \\y &= 0.965(3500) + 0.035(2100 - x)\end{aligned}$$

The first equation represents the number of patients that Doctor Black will have after two years, which includes the 3.5% of patients who moved to Doctor Green's clinic and the 5% of patients who moved to Doctor Black's clinic. The second equation represents the number of patients that Doctor Green will have after two years, which includes the 3.5% of patients who moved to Doctor Black's clinic and the 5% of patients who moved to Doctor Green's clinic.

The first equation represents the number of patients that Doctor Black will have after two years, which includes the 3.5% of patients who moved to Doctor Green's clinic and the 5% of patients who moved to Doctor Black's clinic. The second equation represents the number of patients that Doctor Green will have after two years, which includes the 3.5% of patients who moved to Doctor Black's clinic and the 5% of patients who moved to Doctor Green's clinic.

Simplifying the equations, we get:

$$\begin{aligned}x &= 2009.5 + 0.05y \\y &= 3322.75 + 0.03225x\end{aligned}$$

Substituting the first equation into the second equation, we get:

$$\begin{aligned}y &= 3322.75 + 0.03225(2009.5 + 0.05y) \\y &= 3322.75 + 64.86125 + 0.03225y \\0.96775y &= 3387.61125 \\y &= 3499.743\end{aligned}$$

Substituting y back into the first equation, we get:

$$\begin{aligned}x &= 2009.5 + 0.05(3499.743) \\x &= 2184.985\end{aligned}$$