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Taking advantage of AI and ICT in Mathematics Education: A SWOT Analysis

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About my background and my work

- Mathematics Teacher and Teacher Trainer (France and Tunisia)
- Researcher in Didactics of Mathematics (France)
- Head of Department of Sciences and Technology, Tele-University (French-speaking distance university, Quebec, Canada)
- Full University Professor of Educational Science specialized in ICT and Distance Education (University Paris 7, France)
- Independent Consultant for international bodies and private companies, involved in numerous international projects, especially in Europe and in Africa (worked in 17 African countries).





AI and ICT in Mathematics Education

- Overview
- Strengths
- Weaknesses
- Opportunities
- Threats and Considerations
- Interactive Workshop
- Discussion & Experience Sharing
- Conclusion & Call to Action

A short illustration of “intelligence” in AI



One can ask ChatGPT, in a « natural » way to write a programme in a given language.

Write a program in html that displays for 20 seconds successively an image among a set of 10 photos

Solution obtained in less than 20 s.

ChatGPT gives the requested programme but also useful information that can help an user or a student.

To create an HTML program that successively displays one image from a set of 10 photos for 20 seconds, you can use JavaScript to handle the slideshow logic. Here is an example of HTML, CSS and JavaScript code to do this:



ChatGPT is rephrasing my request, but adding that it will use also CSS and JavaScript code.

Here is the programme

And you can see the result

```
html Copy code
<!DOCTYPE html>
<html>
<head>
  <meta charset="UTF-8">
  <title>Diaporama</title>
  <style>
    #slideshow {
      max-width: 100%;
      max-height: 100%;
    }
  </style>
</head>
<body>
  <div id="slideshow">
    
    
    
    
    
    
    
    
    
    
  </div>

  <script>
    var images = document.querySelectorAll('#slideshow img');
    var currentIndex = 0;

    function showImage(index) {
      for (var i = 0; i < images.length; i++) {
        images[i].style.display = 'none';
      }
      images[index].style.display = 'block';
    }

    function nextImage() {
      currentIndex = (currentIndex + 1) % images.length;
      showImage(currentIndex);
    }

    setInterval(nextImage, 2000); // Change d'image toutes les 2 secondes (2000ms)
  </script>
</body>
</html>
```



Tenerife Island

And an explanation

Make sure to replace "image1.jpg", "image2.jpg", etc., with the actual paths of your 10 images. This code displays images one after the other every 2 seconds (2000 ms) and returns to the beginning when all images have been displayed. You can adjust the duration of the image change by changing the value of set Interval (in milliseconds). **In the example above, it is set to 2000 ms, or 2 seconds. For 20 seconds you will need to set set Interval to 20000 (20,000 ms).**

```
<div id="slideshow">
  
  
  
  
  
  
  
  
  
  
</div>

<script>
  var images = document.querySelectorAll("#slideshow img");
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    showImage(currentIndex);
  }

  setInterval(nextImage, 2000); // Change d'image toutes les 2 secondes (2)
</script>
</body>
</html>
```

Regenerate

AI and ICT in Mathematics Education: Overview

At the primary school level:

- ICT tools may include interactive whiteboards, Educational software applications, online tutorials, and Educational websites.
- These tools aim to enhance engagement, visualization, and conceptual understanding of mathematical concepts through interactive and multimedia-rich experiences.
- At this level, AI can be understood as the use of algorithms and machine learning techniques to assist in the delivery of Mathematics instruction.
- This can also include AI-powered Educational games and interactive learning platforms

How to solve and explain to a primary school student how to calculate $\frac{1}{4} + \frac{2}{3}$?

To explain and solve the addition of $\frac{1}{4}$ and $\frac{2}{3}$ for a primary school student, you can break it down into simple steps and use visual aids to help them understand. Here's a step-by-step guide:

Step-by-Step Explanation

1. Understanding Fractions:

- Explain that fractions represent parts of a whole. For example, $\frac{1}{4}$ means one part out of four equal parts, and $\frac{2}{3}$ means two parts out of three equal parts.

2. Finding a Common Denominator:

- To add fractions, they need to have the same denominator (the bottom number). The denominators here are 4 and 3.
- Find the least common multiple (LCM) of 4 and 3. The LCM of 4 and 3 is 12.

3. Convert Fractions to Equivalent Fractions with the Common Denominator:

- Convert $\frac{1}{4}$ to an equivalent fraction with a denominator of 12.
 - Multiply both the numerator (top number) and the denominator (bottom number) by 3:

$$\frac{1}{4} \times \frac{3}{3} = \frac{3}{12}$$

- Convert $\frac{2}{3}$ to an equivalent fraction with a denominator of 12.
 - Multiply both the numerator and the denominator by 4:

$$\frac{2}{3} \times \frac{4}{4} = \frac{8}{12}$$

4. Add the Fractions:

- Now that the fractions have the same denominator, you can add them by adding the numerators and keeping the denominator the same:

$$\downarrow \frac{1}{12} + \frac{8}{12} = \frac{11}{12}$$

Example with ChatGPT 4o: exercise with fractions

Visual Explanation

1. Use Visual Aids:

- Draw a circle divided into 4 equal parts and shade one part to represent $\frac{1}{4}$.
- Draw another circle divided into 3 equal parts and shade two parts to represent $\frac{2}{3}$.

2. Show Equivalent Fractions:

- Redraw the fractions with the common denominator. Draw two circles divided into 12 equal parts.
- Shade 3 out of 12 parts in the first circle to show $\frac{3}{12}$.
- Shade 8 out of 12 parts in the second circle to show $\frac{8}{12}$.

3. Combine the Shaded Parts:

- Combine the shaded parts in one circle to show that 3 parts plus 8 parts out of 12 parts equal 11 parts out of 12 parts, or $\frac{11}{12}$.

Simplified Steps for Primary Students

- Find a Common Number:** Help them find a common number (denominator) that both 4 and 3 can become.
- Make the Fractions the Same:** Change $\frac{1}{4}$ to $\frac{3}{12}$ and $\frac{2}{3}$ to $\frac{8}{12}$.
- Add the Top Numbers:** Add the numerators: $3 + 8 = 11$.
- Keep the Bottom Number:** Keep the denominator 12 the same.

By breaking it down into these steps and using visual aids, you can make the process of adding fractions more understandable for primary school students.

Example with ChatGPT 4o: exercise with fractions

could you read aloud: $3/4 + 5/6 = 1\ 7/9$



Sure, here is how you would read aloud the expression $\frac{3}{4} + \frac{5}{6} = 1\frac{7}{9}$:

"Three fourths plus five sixths equals one and seven ninths."

(Note: The correct answer to $\frac{3}{4} + \frac{5}{6}$ is actually $1\frac{7}{12}$, not $1\frac{7}{9}$. This might have been a typo. The correct statement should be:

"Three fourths plus five sixths equals one and seven twelfths.")



Message ChatGPT



ChatGPT peut faire des erreurs. Envisagez de vérifier les informations importantes.

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Message ChatGPT



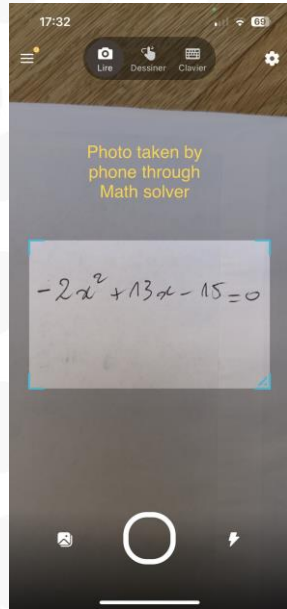
ChatGPT peut faire des erreurs. Envisagez de vérifier les informations importantes.

AI and ICT in Mathematics Education: Overview

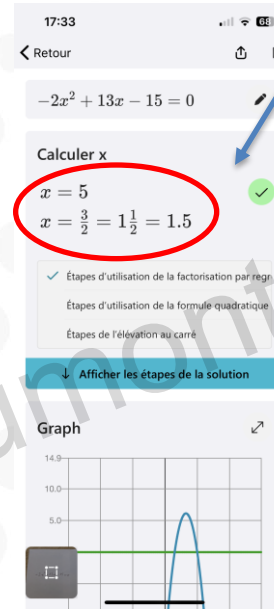
At the secondary school level:

- ICT tools play an interesting role in Mathematics Education by offering advanced visualization capabilities, simulation tools, and access to vast online resources, interactive exercises, and opportunities for collaborative learning and discussion.
- AI applications in Mathematics Education become more sophisticated. For instance, AI-powered virtual tutors can guide students through complex mathematical problems, offering hints and explanations, possibly by offering the students the opportunity to pose their problems by writing it by hand.

Example with Math Solver: question based on a hand-written equation



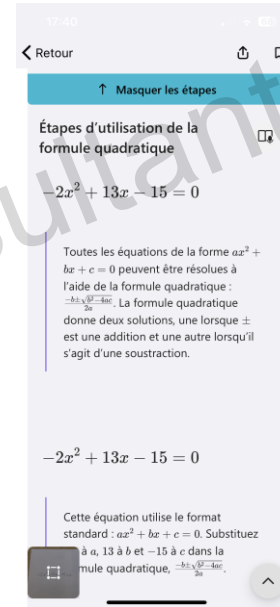
Even with poorly written numbers (like the 5) the apps correctly interprets my equation.



Here are the two solutions.

Interesting remark:
The second one is given in 3 different forms.

It is possible to choose the method to be developed ...



... and then get the explanation step by step

Vidéos



Problèmes similaires dans la recherche Web



On top of it, some videos are recommended to reinforce the understanding

AI and ICT in Mathematics Education: Strengths

- Their ability to enhance teaching effectiveness and improve learning outcomes through various means:
 - Personalized Learning and Instant Feedback and Assessment, using tutoring systems
 - Interactive Learning Experiences as simulations and virtual laboratories
 - Concept Reinforcement and Remediation, with Concept Mapping Tools and Intelligent Problem-Solving Tools
 - Conversational Agents, engaging students in natural language dialogue, answering questions, providing explanations, and facilitating interactive problem-solving sessions in real-time.
 - Access to online Resources and Collaborative Learning Environments
 - AI-powered Educational games and apps, to make learning math fun and engaging, fostering intrinsic motivation and deeper conceptual understanding.



Write as a mathematical formula: sum, for $n = 0$ to $n=k$, of $\cos^2 (n\pi/2)$



Certainly! The mathematical formula for the sum of $\cos^2 \left(\frac{n\pi}{2} \right)$ from $n = 0$ to $n = k$ can be written as:

$$\sum_{n=0}^k \cos^2 \left(\frac{n\pi}{2} \right)$$

This represents the sum of the squares of the cosine function evaluated at $\frac{n\pi}{2}$ for each integer n from 0 to k .



AI and ICT in Mathematics Education: Weaknesses

- Overreliance on Technology:
 - Excessive reliance on AI and ICT tools may lead students to focus more on algorithmic solutions rather than developing deep conceptual understanding.
 - Belief in the infallibility of AI tools may lead students to accept without critical thinking results and solutions although some may be incorrect.
- General weaknesses (not specific to Mathematics Education)
 - Loss of Human Interaction
 - Teachers not enough trained

About Weaknesses: A problem quickly - too quickly? - solved by Chat GPT

One can ask ChatGPT, also in a « natural » way, to solve a problem, like this one:

Find a polynomial function of the 3rd degree passing through the points A (5; 2), B (1; -1), C (2; 0) and D(0; 3)

Solution obtained in less than 25 s:
$$f(x) = -\frac{7}{360}x^3 + \frac{59}{120}x^2 + \frac{109}{120}x + 3$$

ChatGPT writes the answer with the usual mathematical notation and gives several clues about the method to be followed and is developing the calculus until the end.

About Weaknesses: A problem quickly - too quickly? - solved by Chat GPT

- So ChatGPT is able to describe a correct method and to use it, but as some good students who sometimes are going too fast, it can make errors (of inattention?), in this case an error of sign.
- Even if ChatGPT produces credible answers, it can make mistakes, invent facts, events... so it is important when using this kind of tools:
 - To train students in critical thinking
 - To develop their ability to verify facts
- This kind of interaction with ChatGPT could give to teachers a lot of opportunities to work with their students on mathematical issues but also on the advantages AND the limitations of such conversational tools.

AI and ICT in Mathematics Education: Opportunities

- Virtual Reality (VR) and Augmented Reality (AR) could be used to create immersive and interactive mathematical simulations, allowing students to visualize abstract concepts, explore mathematical structures, and engage in hands-on experimentation.
- Virtual manipulatives could provide tactile experiences for students, for instance, to manipulate geometric shapes, visualize transformations, and explore spatial relationships in three-dimensional environments.
- Future generation of AI-powered serious games could simulate real-world mathematical problems and scenarios, challenging students to apply mathematical concepts in authentic contexts and develop problem-solving skills.

AI and ICT in Mathematics Education: Threats and Considerations

- Superficial Learning: AI-driven adaptive learning systems may prioritize performance metrics over deep conceptual understanding, leading to a focus on algorithmic problem-solving rather than critical thinking and conceptual mastery.
- General threats and considerations (not specific to Mathematics Education)
 - Lack of Human Assessment
 - Loss of Teacher Autonomy
 - Access and Equity Issues, leading to a digital divide and technology literacy gap
 - Ethical Concerns, i.e. biased AI algorithms possibly leading to inequitable outcomes and reinforcing stereotypes in Educational settings
 - Privacy Concerns, for instance about collecting and storing student data
 - Dependency on Commercial Providers

Interactive Workshop: With Math Solver and Photomath

- With Math Solver and Photomath

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Interactive Workshop: With ChatGPT

1. Test its capacity to solve various math problems
2. Engage discussion with ChatGPT for instance on the following questions:
 - Which AI tool can I use in geometry?
 - What can I do with Math Solver from Microsoft?
 - What are the main difficulties in teaching fractions?
 - What geometry problems can be solved with a ruler and a compass?
 - What would you advise me to teach trigonometry in high school?
 - What should I avoid doing in high school to make people understand the notion of infinite limit?

AI and ICT in Mathematics Education: Discussion and Experience Sharing

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AI and ICT in Mathematics Education: Conclusion

- By harnessing the power of AI and ICT in Mathematics Education, educators can create inclusive, adaptive, and transformative learning experiences that empower students to discover Mathematics in a more motivating way, to overcome their difficulties, to better understand mathematical concepts and to better master mathematical reasoning.
- Despite the opportunities presented by these technologies, it's important to be mindful of the ethical considerations, equity concerns, and societal implications that accompany their implementation.
- Above all, we should promote the development of critical thinking in our students and future citizens.

Call to Action

- Encourage collaboration between educators, technologists, and policymakers to maximize the benefits of AI and ICT in Mathematics Education



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THANK YOU

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