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ORIGINAL STUDY

Analysis of the Use of Technology in Teaching Differential Equations and Their Practical Applications

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Abstract

Differential equations are considered one of the important topics in applied mathematics, physics, and engineering. Thanks to technological progress, it has become possible to use technology in teaching differential equations in innovative and effective ways. The use of technology in teaching differential equations helps improve students' understanding and enhance their abilities in solving practical and applied problems. The goal of the research is to indicate that the use of interactive software and applications allows the creation of a dynamic and interactive learning environment. Students can change equations and parameters and explore to learn about the results and relationships between them. The use of technology provides powerful analytical tools and simulations for differential equations. Students can analyze mathematical behavior graphically and visualize expected solutions. The study concluded that technology is available access to online educational resources, like educational videos, detailed learning materials, and discussion forums that help students understand basic concepts and apply them in solving problems. Using technology, students can perform digital experiments and simulations of complex differential equations that cannot be performed manually. They can change parameters and boundary conditions and explore their effect on solutions, which helps them on understanding the behavior of the equation and various interactions.

Keywords: Technology, Differential equations, Practical applications

1. Introduction

Differential equations are considered one of the important topics in applied mathematics, physics, and engineering. Thanks to technological progress, it has become possible to use technology in teaching differential equations in innovative and effective ways. The use of technology in teaching differential equations helps improve students' understanding and enhance their abilities in solving practical and applied problems, as it contributes Some applications of technology in teaching differential equations are that many specialized mathematical programs are available for solving differential equations, such as MATLAB, Maple, and Mathematica. These programs allow students to enter equations and solve them easily and quickly using digital computing, through which students can

verify their solutions and analyze the results in detail.

Also, Technology can be used to create models and simulations of differential equations. Students can use simulation software to create interactive models representing physical phenomena and practical applications that rely on differential equations. They can analyze the behavior of the system based on different inputs and experiment with changing parameters to understand their effect on the results.

In addition, technology can be used to provide differential equations lessons online, allowing students to access various interactive educational resources. Video lessons can be recorded and streaming lectures can be created that students can access at any time and from anywhere. Interactive platforms can also be provided that allow students to solve problems and practice.

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Concepts through practical applications, many portable applications help students solve differential equations and understand related concepts. These applications also provide simple and interactive interfaces that allow students to enter equations, see solutions, and graphical analysis of the results. Students can use these applications while studying or in solving practical problems.

In daily life, the use of technology in teaching differential equations provides opportunities for effective interaction, experimentation, and practical application. Students can also benefit from modern tools to analyze and visualize complex mathematical concepts and apply them to real-life problems. This approach helps enhance understanding and develop the practical skills necessary to solve differential problems in the fields of different things like science and engineering.

However, technology should be used as an auxiliary tool in the learning process and should not replace the direct interaction between the teacher and the student. There must be a balance between the use of technology and traditional methods of teaching differential equations to ensure a comprehensive and effective educational experience.

2. The research problem

When looking at the use of technology in teaching differential equations, some potential problems can be identified:

1. Some students may have difficulty accessing appropriate technology for learning differential equations, and some students may have financial or technical constraints that prevent them from accessing the required hardware and software. This problem must be taken into account and alternative options must be provided for students to access educational materials and appropriate technology.
2. Providing high-quality educational resources for learning differential equations using technology can be a challenge, so it is necessary to ensure that the resources used provide explanations, examples, and exercises that are appropriate to the level of the students and contribute to achieving the desired educational goals.
3. There may be a risk of over-reliance on technology in teaching differential equations. There must be a balance between using technology and developing skills in solving differential equations manually. Students must understand the theory and basic concepts and develop the

ability to solve problems manually to enhance critical thinking and a deep understanding of the subject.

4. Some technological technologies may have difficulty providing feedback and error analysis effectively. Error analysis and feedback are an important part of the learning process, as students can benefit from the feedback and correct their mistakes. Technology should provide effective mechanisms for analyzing errors and providing feedback to students.
5. Heavy reliance on technology can be a challenge for students to communicate with the teacher and each other. Technology must provide mechanisms for effective communication and interaction between students and teachers, whether through distance learning platforms or collaborative programs. There must be a balance between using technology and providing opportunities for personal communication and interaction in the learning environment.

These are some of the potential problems that may be encountered when using technology in teaching differential equations. These problems must be dealt with carefully and appropriate support and guidance provided to students to ensure an effective and comprehensive educational experience.

3. Importance of research

The use of technology in teaching differential equations is of great importance and can have positive impact on the learning process. Here are some reasons that highlight the importance of using technology in teaching differential equations:

1. Enhancing interaction and experience, as the use of technology allows the creation of an interactive learning environment that encourages students to explore concepts and experience various scenarios. Students can enter equations, change parameters, and see results immediately. This interaction can deepen understanding and enhance confidence in solving differential equations.
2. Providing powerful analytical tools. Mathematical software and portable applications provide powerful analytical tools to understand and study the mathematical behavior of differential equations. Students can visualize solutions graphically and analyze their various properties such as level, slope, and fixed points, and this helps in developing mathematical concepts and mathematical insight.

3. Benefiting from project-based learning, where technology can be used to enable students to create applied projects based on differential equations. Students can also build models and simulations of physical phenomena or dynamic systems and use differential equations to analyze them. This enhances practical learning and the application of theoretical concepts to real problems.
4. Providing diverse educational resources. Through the use of technology, it is possible to create diverse educational resources that are easily available to students. Video lectures, interactive materials, applied exercises, and electronic educational files can be developed, so that students can access these resources at any time and from anywhere, which enhances practical flexibility, learning allows them to learn at their own pace.
5. Developing analysis and programming skills, as programming and using mathematical software is considered an essential part of solving differential equations using technology. Students cannot develop mathematical analysis and programming skills by writing codes and implementing them to solve differential equations. This allows them to learn different programming languages and apply them in solving mathematical problems.

In general, the use of technology in teaching differential equations can make the educational process more effective and interesting. It can help expand students' horizons and enhance their understanding of mathematical concepts. It can also contribute to developing analysis and programming skills that are valuable in many other fields as well.

4. Research objectives

The use of technology in teaching differential equations aims to achieve several objectives, including:

1. The use of technology helps clarify difficult and abstract concepts associated with differential equations. Graphs can be visualized and interacted with differential models on the screen to help students understand the mathematical behavior of equations and the influence of different parameters on solutions.
2. The use of interactive software and applications allows for the creation of a dynamic and interactive learning environment. Students can change equations and parameters and explore to

learn about the results and relationships between them. This allows students to experiment and self-discover and enhance critical thinking and creativity.

3. The use of technology provides powerful analytical and simulation tools for differential equations. Students can analyze mathematical behavior graphically and visualize expected solutions. Simulations of the system's interaction over time can be carried out, helping students better understand physical and dynamic phenomena.
4. The use of technology provides powerful analytical and simulation tools for differential equations. Students can analyze mathematical behavior graphically and visualize expected solutions. Simulations of the system's interaction over time can be carried out, which helps students better understand physical and dynamic phenomena.
5. Students can use technology for self-learning and develop their skills in solving differential equations. They can access various online educational resources, mobile applications and interactive educational platforms. They can also use the software to develop their own projects and improve their problem-solving skills
6. Technology can enhance interaction and collaboration between students and teachers. Online learning platforms can be created for resource sharing, discussion, and joint learning in which students can also interact with others through discussion forums or group chats to discuss ideas and solve complex issues.

In short, the use of technology in teaching differential equations aims to improve understanding and practical application and enable students to explore and experience concepts in interactive and simulated ways. Technology can also enhance cooperation and social interaction in the learning process.

5. Structuring the research

The first topic: Using technology in teaching differential equations.

The first requirement: The role of technology in analyzing complex mathematical concepts.

The second requirement: The role of technology in improving computational capabilities.

The second topic: Scientific applications of differential equations.

The first requirement: Scientific applications of differential equations in physics.

The second requirement: The use of differential equations in computer science.

6. The first topic: the use of technology in teaching differential equations

6.1. The first requirement: the role of technology in analyzing complex mathematical concepts

Science and technology can be used in teaching mathematics in several ways, where one of the ways is the use of technology-enhanced learning tools, such as interactive simulations, virtual manipulations, and educational games. Online tools can help students visualize and interact with mathematical concepts. These tools can also help students practice problem-solving and develop critical thinking skills [1].

Another way science and technology can be used in mathematics education is to use real-world applications and examples. By incorporating real-world data and problems into mathematics lessons, teachers can help students see the importance of mathematics in science, technology, engineering, and other fields. This can help students become more engaged in their learning and develop a deeper understanding of mathematical concepts [2].

In addition, science and technology can be used in mathematics education to help students develop problem-solving skills. For example, teachers can use programming languages and robotics to teach students how to write algorithms and solve problems through programming, which can help students develop logical thinking and creativity and problem-solving skills that can be applied in many areas of their lives.

In general, using science and technology in mathematics education can help students develop a deeper understanding of mathematical concepts, engage with their learning, and develop valuable problem-solving skills that can benefit them in many ways and their areas of life.

Mathematics is the language of the universe and is considered the basis for many applications in science and technology. Technology can play a decisive role in developing this field and enhancing mathematics capabilities. These are some of the reasons that highlight the importance of technology in the world of mathematics [3].

1. Technology can provide enormous computational power to solve complex mathematical problems. It can process many mathematical operations in a very short period with high accuracy and speed.

2. Technology can detect complex patterns and relationships in mathematical data. It can analyze complex mathematical processes and identify underlying patterns and trends.
3. Using technology, accurate mathematical models can be developed that contribute to a better understanding of mathematical concepts and provide powerful tools for data analysis.
4. Thanks to technology, innovative solutions can be developed and performance can be improved in areas such as cryptography, numerology, statistics, etc.

Technology is one of the modern technological innovations that offer great opportunities in the field of mathematics. Thanks to the enormous computational power of technology, mathematics can expand the limits of possibilities and creativity in analyzing mathematical data. And developing new models that enhance our understanding of the universe around us.

6.2. The role of technology in solving mathematical problems

Introducing complex mathematics. Technology is a powerful tool in solving complex mathematical problems. Technology can be used to solve a wide range of mathematical problems, including problems of high dimensions and great complexity [4].

The Boltzmann machine is one of the examples of algorithms that can be used to provide solutions to complex mathematical problems. This machine is based on the concept of artificial neural networks and can be used in many fields such as data analysis and machine learning. Using technology, we can transform enormous computational power into creative and effective solutions to problems. Mathematical technology can analyze and understand complex patterns and data, build predictive models for the future, and improve performance over time [5].

Providing quick and effective solutions as technology improves the efficiency and speed of solving mathematical problems instead of relying on tedious and expensive manual calculations to solve mathematical problems, technology can perform calculations with extreme speed and accuracy.

Using technology, data can be analyzed very quickly and patterns and trends can be extracted. Technology can also provide innovative and effective solutions to mathematical problems, adapt to changes, and continually improve. In addition, technology can organize and store data in an organized and easily accessible manner.

By using technology in mathematical problems, it is possible to improve information management and facilitate the decision-making process. Using technology, tremendous development can be achieved in the field of solving mathematical problems and providing fast, effective, and innovative solutions. Technology may be the key to an amazing computational future and development in the field of mathematics.

6.3. *The second requirement: the role of technology in improving computational capabilities*

Technology plays an important role in improving individuals' computational capabilities in several aspects, and here are some examples of how technology plays a role in enhancing computational capabilities:

1. Technology such as calculators, smartphones can speed up and facilitate complex and advanced calculations, and thanks to computational tools, individuals can perform calculations more quickly and avoid common human errors.
2. Technology provides extensive educational means and resources for learning arithmetic skills, and individuals can access educational computer programs and applications, websites, educational videos, and discussion forums to enhance their understanding and practice of arithmetic skills.
3. Technology can provide an interactive environment for individuals to practice arithmetic skills and receive immediate feedback. For example, interactive computer programs and educational games can be used to help analyze errors and provide guidance for improving arithmetic performance.
4. Technology makes it possible to customize and adapt educational and training experiences according to the needs of individuals. Programs and applications can provide various arithmetic exercises and tasks and different levels of difficulty to match the skill level and individual needs [6].
5. Interactive and Visual Learning: Technology can provide interactive and visual learning experiences that help individuals better understand computational concepts. Through the use of animated graphics, simulations, and interactive models, mathematical concepts can be more clearly illustrated, and complex mathematical relationships can be illuminated.

In general, technology can provide a diverse and interactive learning environment that contributes to improving the mathematical abilities of individuals. However, technology must be used as an auxiliary and complementary tool for learning, and one should not rely entirely on it. A balance must be taken between using technology and developing basic concepts and skills in calculations, and motivating students to think critically and solve problems in different ways [7].

Arithmetic is one of the basic skills in mathematics that requires regular practice to develop. However, providing appropriate and personalized practice for each student can be challenging for teachers and parents to provide an effective learning experience.

Technology can be a valuable tool for providing personalized arithmetic practice. Technology can analyze mathematical data and provide insights that are relevant and tailored to each student based on their abilities, strengths, and weaknesses.

By analyzing a student's performance on arithmetic exercises and tests, technology can identify the areas where the student needs to focus and provide appropriate exercises to help them develop their skills. By leveraging machine learning and mathematical analytics, technology can provide valuable insights into the best ways to improve students' mathematical abilities and develop mathematical skills. It can also customize each student's experience based on their current mathematical level and skill set [8].

Using technology, exercises, and drills can be customized for each student based on their individual needs. Students benefit from interactive exercises and mathematical challenges specifically designed to help them develop their mathematical skills and increase their confidence in mathematics. Technology can also monitor student performance progress and provide direct feedback and personalized guidance to help with continuous improvement [9].

In these ways, technology can contribute to improving students' mathematical abilities providing an enhanced and personalized learning experience for each student through the use of mathematical analysis and machine learning techniques, technology can transform computational power into creativity in improving the soil of mathematical learning.

Technology is considered one of the latest technologies in designing educational games that aim to

transform the learning process into an interactive and enjoyable experience. Technology designs educational games by analyzing the player's performance and adjusting the challenge levels based on the player's understanding and speed of interaction. This helps students improve mathematics skills in innovative and motivating ways and can also take advantage of technology to create unique learning experiences tailored to each individual and tailored to the needs of students.

7. Section two: scientific applications of differential equations

Differential equations play an important role in several scientific applications. Here are some common applications of differential equations in science:

1. Physics

Differential equations are used in physics to describe many natural phenomena. For example, differential equations are used in fields such as classical dynamics, fluid mechanics, quantum mechanics, and Albert Einstein's theory of relativity [2].

2. Engineering

Differential equations are used in engineering to solve problems of control, thermodynamics, vibrations, electric currents, and electromagnetic fields. Differential equations help in understanding and describing the behavior, design, and analysis of engineering systems.

3. Life Sciences

Differential equations are used in the life sciences to describe many biological processes such as the spread of diseases, cell reproduction, organ regulation, and the dynamics of ecosystems. These equations help in understanding biological interactions and predicting biological behavior [1].

4. Computer Science and Artificial Intelligence

Differential equations are used in developing mathematical models of technology and machine learning. These equations help in analyzing data, predicting behavior, and developing machine-learning techniques.

5. Medical Sciences

Differential equations are used in medical sciences to describe vital processes in the body such as the transport of drugs in tissues, interactions of

biological organs, and the spread of fever. These equations help in understanding and analyzing biological systems and designing treatments.

These are just a few examples of applications of differential equations in science, and there are certainly many other fields where these equations are used to solve complex problems and clarify mathematical relationships between variables in many scientific disciplines [3].

7.1. The first requirement: scientific applications of differential equations in physics

Differential equations are considered a powerful tool in solving a variety of physical problems. Common scientific applications of differential equations in physics include:

1. **Classical Dynamics:** Differential equations are used to study the motion of bodies and mechanical systems. For example, Newton's law of motion can be represented by a second-order differential equation.
2. **Thermodynamics:** Differential equations are used to study heat transfer and heat balance. For example, the thermal diffusion equation (Fourier equation) is a differential equation that describes the distribution of heat in a heat-conducting medium.
3. **Quantum Dynamics:** Differential equations are used to describe quantum states and their evolution. For example, the Schrödinger wave differential equation describes the evolution of the wave function of quantum particles.
4. **Electromagnetic dynamics:** Differential equations are used to describe electric and magnetic fields and the propagation of electromagnetic waves. For example, Maxwell's equations are a set of differential equations that describe the behavior of electric and magnetic fields [10].
5. **Astroynamics:** Differential equations are used to study the motion of celestial bodies and cosmic phenomena. For example, Newton's equations of gravitation describe the motion of planets and other celestial bodies.
6. **Fluid Dynamics:** Differential equations are used to study fluid flow and fluid dynamics. For example, the Navier–Stokes equations describe the motion of incompressible fluids [10].

These are some common applications of differential equations in physics. These equations are used to describe many physical phenomena and solve complex problems in various fields such as mechanics, heat, electromagnetism, planets, and fluids.

7.2. The second requirement: the use of differential equations in computer science

The practical aspect of differential equations is used in computer science and artificial intelligence for several purposes, including these areas:

1. **Machine Learning:** Differential equations are used to develop mathematical models that simulate the behavior of biological, social, and economic systems and processes. These models are improved using differential optimization and self-adaptation algorithms, which use differential equations to update and improve parameters and weights in educational models.
2. **Image processing and computer vision:** Differential equations are used in image analysis and computer vision, such as edge detection, feature extraction, and object tracking. Images are converted into differential equations to describe the behavior of pixels and understand the structures and shapes in images [11].
3. **Modeling of dynamic systems:** Differential equations are used in modeling and analyzing dynamic systems in the field of computer and artificial intelligence. These equations are used in the design and analysis of robots and intelligent systems, tracking the movement of objects, and controlling industrial processes.
4. **Data Analysis and Forecasting:** Differential equations are used to analyze data and predict future behavior. For example, differential equations can be used to analyze long time series, analyze vibrations and fluctuations, and predict the behavior of financial markets and the strategic direction of business [12].
5. **Artificial neural networks:** Differential equations are used in designing and training artificial neural networks. These equations are used to determine the weights and internal coefficients of the neural network and improve its performance by modifying these coefficients using digital differential algorithms [13,14].

8. Conclusion

Analysis of the use of technology in learning differential equations refers to the systematic study and evaluation of how technology is used in the process of learning and understanding differential equations. Differential equations are considered one of the main tools in applied mathematics and engineering sciences and are used to describe many processes and phenomena in the

real world. Modern technology offers a variety of Educational tools and programs that can be used to enhance understanding of differential equations. Through various computer programs and interactive tools, students can manipulate equations, solve them, explore results visually, and try different scenarios.

9. Results

1. Technology also provides access to online educational resources, such as educational videos, detailed teaching materials, and discussion forums that help students understand basic concepts and apply them to solve problems.
2. Using technology, students can also perform digital experiments and simulations of complex differential equations that cannot be performed manually and can change parameters and boundary conditions and explore their effect on solutions, which helps them understand the behavior of the equation and various interactions.
3. However, there must be a balance and consistency between the use of technology and traditional education. Despite the benefits of technology in learning differential equations, it cannot replace the deep understanding of mathematical concepts and critical thinking required to solve problems.
4. Therefore, the use of technology in learning differential equations is a powerful tool that can support and enhance the educational process, and contribute to providing a more interactive and interesting educational experience for students. With the use of correct guidance and good organization, technology can be a valuable tool in enabling students to develop their skills in solving differential equations and their application in science and engineering.

10. Recommendations

Based on the analysis of the use of technology in learning differential equations, here are some recommendations that can be taken into consideration:

1. Computer programs and interactive tools must be provided that help students learn differential equations in an in-depth and effective manner. These means may include specialized computer programs, mobile applications, and other digital tools that contribute to clarifying concepts and facilitating problem-solving.

2. Technology should be used under teacher guidance to enhance and supplement basic aspects of learning and students should be guided to understand mathematical concepts and utilize technical tools to apply these concepts in solving practical problems.
3. Students should be encouraged to interact with the technology and explore various scenarios and experiments. They can change parameters and conditions and see their effect on solutions, which helps them better understand the relationship between equations and results.
4. Students can take advantage of online educational resources such as educational videos, detailed materials, and discussion forums. These resources provide detailed explanations of concepts and provide illustrative examples that help students better understand differential equations.
5. Technology can provide immediate performance assessment and give direct feedback to students. This feature can help identify areas where students need to improve and provide immediate feedback to enhance learning.
6. Students should receive appropriate training on how to use software and technical tools to solve differential equations and this may include being instructed to learn basic interfaces and commands and how to interpret and analyze the results produced.
7. Simulations and educational games can be used to make the process of learning differential equations more fun and interactive, and students can participate in interactive activities that allow them to experience many scenarios and practical applications of differential equations.
8. Specialized technical and technical support should be provided to students and teachers when using technology to learn differential equations and there should be a specialized team who can provide assistance and guidance regarding technical tools and applications.

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