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MIT App Inventor: A Tool for Enhancing Technological Pedagogical Content Knowledge

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ABSTRACT

Today, with increasing access to the internet and portable computing tools, the possibility of utilizing these tools in education has significantly expanded. Consequently, various tools have been introduced for creating and developing content and designing mobile-based educational courses. One of the essential and widely used tools for content creation and mobile-based course development is the MIT App Inventor tool, developed by a group of researchers at the Massachusetts Institute of Technology (MIT). It requires guidance on using this technology tool for content production in designing and implementing practical educational courses in health-related domains. This article aims to introduce the App Inventor software and its utilization in Technological Pedagogical Content Knowledge (TPACK). The tool is particularly beneficial for individuals outside the tech industry who seek to incorporate educational applications into teaching and learning processes.

Keywords: MIT App Inventor, Technological Pedagogical Content Knowledge, TPACK, Mobile Learning, Educational Applications, Visual Programming

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Introduction

Mobile devices, including phones and tablets, are the most common digital technologies. While desktop and laptop ownership is declining, mobile technology usage is rapidly expanding. The evidence indicates that mobile phone and tablet use is increasing among all age groups, including children, adolescents, and adults (1-3).

The swift growth of new-generation mobile devices and the frequent use of wireless technology have highlighted the substantial learning potential of mobile devices, making them practical tools for education (4). The emergence of mobile technology has not only introduced innovative interpersonal communication but has also given rise to a new learning model known as mobile learning or m-learning. Mobile learning supports distance education, facilitated by mobile devices with wireless technologies. Mobile learning technology represents an evolving model and process that demands new forms of teaching, learning, content, and dynamic interactions among stakeholders. Mobile learning technologies provide educators and students with a more flexible approach to learning. Mobile devices have more excellent capabilities in creating and personalizing learning resources, allowing students to use computing and communication technologies for information access anywhere and anytime (1).

The evolution of mobile applications

has been significant, with advancements in software, service platforms, and capabilities. Today, mobile apps are sophisticated, feature-rich, and integral to daily, professional, and educational activities. This new era has seen the rise of mobile apps as an essential tool, driven by advancements in technology and software platforms (5). Integrating applications into education has brought significant benefits, especially in the field of health sciences. Educational apps support intelligent and systematic learning, providing well-organized information to enhance students' engagement. Incorporating apps into education gives students a safe space to interact with mobile technology while learning, fostering a dynamic learning environment. These apps offer advantages for both teachers and parents, enabling teachers to utilize them in the classroom effectively. In the medical education sector, there is a growing demand for interdisciplinary subjects to be integrated into the curriculum, highlighting the need for innovative educational approaches. The development of educational applications involves a strategic process that leverages technologies to create engaging and effective learning tools (6).

However, creating educational or medical apps with advanced functionalities demands technical expertise, which can be challenging for non-technical users like medical educators (7). Teachers also need a variety of knowledge, including technology-based knowledge. For this purpose, they can benefit significantly from acquiring knowledge about TPACK (Technological Pedagogical Content Knowledge), a framework that emphasizes integrating technology into teaching practices. TPACK comprises three main components:

- **Technological Knowledge (TK)**: This component focuses on teachers' understanding of how specific technologies can impact teaching and learning processes.
- **Pedagogical Knowledge (PK):** It pertains to teachers' expertise in instructional methods and strategies for effectively delivering content to students.
- **Content Knowledge (CK)**: This component refers to teachers' deep understanding of the subject matter they teach.

By combining these three components, teachers can enhance their teaching practices by effectively integrating technology into their lessons to improve student learning outcomes. Understanding TPACK provides educators with a structured approach to leverage technology in the classroom for more engaging and effective teaching (8, 9). This paper introduces App Inventor as an accessible tool to simplify the development of mobile apps for intelligent learning experiences (Figure 1).

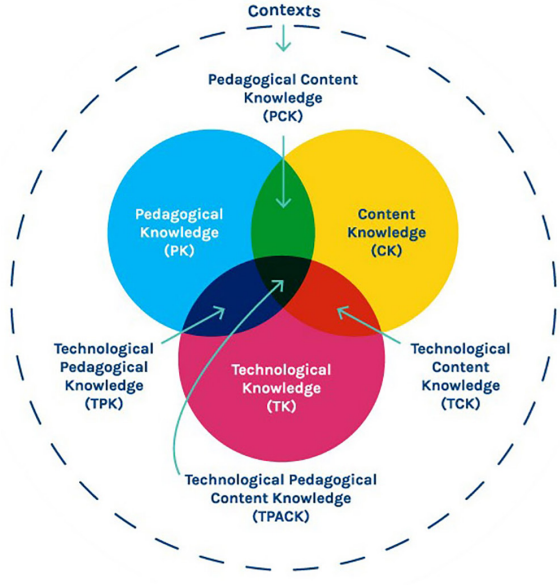

Figure 1: Integrated Technological Pedagogical Content Knowledge (9).

MIT App Inventor Tool

MIT App Inventor is a mobile application development tool that enables individuals without deep programming knowledge to create interactive and practical Android applications. Developed by a group of researchers at the Massachusetts Institute of Technology (MIT), the MIT App Inventor's primary goal is to facilitate mobile application development through a block-based approach. Key features of this platform include being free, providing access to program source code (open source), hardware and software independence (platform-neutral), and accessible learning (simplicity and no need for deep programming skills) (7) (Figure 2).

Figure 2: Key features of MIT app inventor (7).

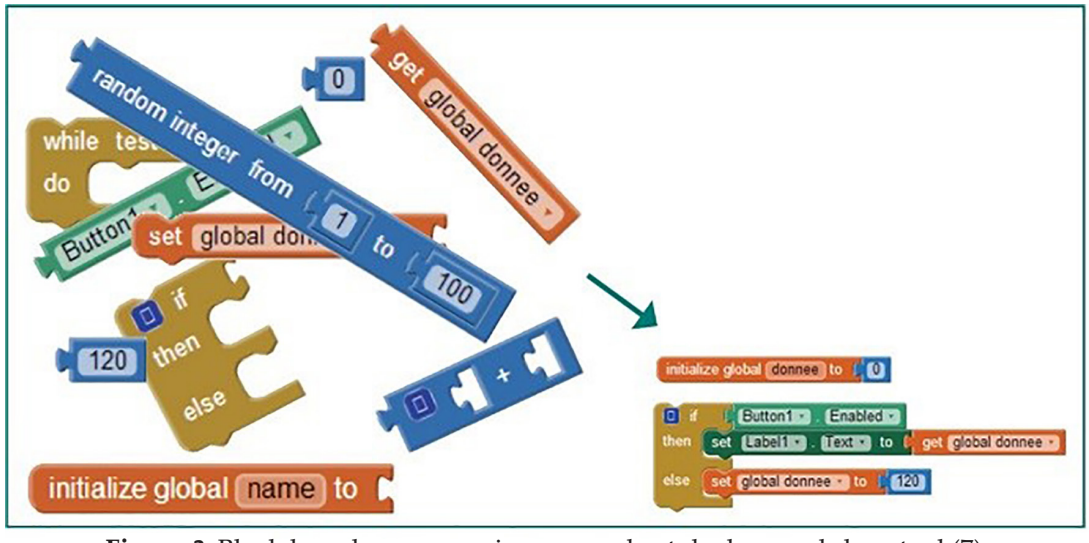

Figure 3: Block-based programming; a puzzle-style drag-and-drop tool (7).

Features and Key Characteristics of MIT App Inventor Tool

- **Visual Programming:** MIT App Inventor utilizes visual programming, providing pre-built and ready-to-use commands in various geometric shapes and colors. Users can define the logic and functionality of their programs by dragging and dropping these shapes, combining them like a puzzle to implement their ideas (Figure 3).
- **Live Preview and State Analysis:** MIT App Inventor allows users to test their applications in real-time on Android devices or Android emulators during the development process (Figure 4).
- **Component Library:** MIT App Inventor is equipped with a library of components and various tools that users can utilize to create diverse features based on their application's needs. This library includes UI design tools such as buttons, lists, layouts, images, videos, etc.
- **Integration with Distributed Services:** By leveraging various components and features, users can create applications that communicate with online services, such as databases, web services, and other internet-based services.
- **Education and Documentation:** MIT App Inventor offers rich educational resources to assist users in becoming familiar with the concepts and development methodologies for creating applications using this tool.
- **User Community:** MIT App Inventor has an online community where users can share their experiences, projects, and questions.

MIT App Inventor Features in Alignment with TPACK Challenges

The TPACK model underscores the importance of aligning technology with content and pedagogical knowledge in education. It presents challenges such as rapid technological changes, inappropriate software design, learning context issues, and a focus on "what" rather than "how." The MIT App Inventor, a mobile and tablet-based platform, is proposed to address these challenges.

Figure 4: The possibility of live testing in App Inventor (7).

It boasts simplicity, easy learning, adaptability, customization options, platform neutrality, open-source availability, and cost-effectiveness.

Teachers can easily create educational applications using MIT App Inventor's visual programming and library tools, fostering direct interaction with students. By developing these applications, students gain skills in analysis, critical thinking, and active participation in learning and knowledge production. The platform enhances practical experience, encouraging genuine student interaction, creativity, critical thinking, and computational skills.

Evidence from MIT App Inventor Implementation in Education

App Inventor has been used in various contexts. The results of some of these studies are stated below:

In a study conducted by Dunand, the MIT App Inventor was employed to design a training course for learners aged 13 to 18 on the principles of visual accessibility. A new feature in this tool, specifically the recent addition that enabled the users to modify the size of text and images, was evaluated regarding its impact on improving student learning (10).

leveraging the visual capabilities of MIT App Inventor and the ease of quickly transforming ideas into outputs in a study carried out by Hsu and colleagues, the tool was utilized for teaching applications of artificial intelligence (11). Students in this study had to learn how to develop a smartphone application using MIT App Inventor to detect and translate control cards into machine movements. Given that MIT App Inventor has incorporated functions related to machine learning and packaged complex processes into modules, users can focus on using machine learning technology to address specific issues

for individuals or groups. Several studies indicate the effectiveness of using this tool in learning artificial intelligence concepts and its practical understanding (11, 12).

In another study by Hsu and colleagues, MIT App Inventor was used to design a collaborative programming environment for educational purposes. A real-time collaborative environment was created, allowing learners to develop a programming project collectively using MIT App Inventor (12).

Zhou and colleagues employed MIT App Inventor to design a machine learning course in image processing. Using the mobile phone camera, relevant images were introduced into the mobile phone for training and testing, and students developed a block-based program to identify images based on machine learning principles (13).

In another study, a mobile application development project for health information technology was designed using MIT App Inventor. Mobile health and treatment applications were introduced to enhance students' understanding of health information technology and the role of information technology applications in healthcare. Analysis of the students' feedback indicated the effectiveness of the tool's simplicity, real-time experimentation, and ease of use in teaching students without programming skills (14).

According to the analysis of a recent survey of RUSE University students over three consecutive years (2016- 2018), involving 73 students (11 females and 62 males), MIT App Inventor was introduced as the most suitable tool for providing effective technology-integrated education at the undergraduate and postgraduate levels, considering its features such as ease of project production, powerful media utilization, and standardized output presentation (15). In some research, MIT App Inventor was utilized for teaching programming in a summer school for high school students in the field of computer science. The key reasons for using this tool were the ease of block programming and the acceleration of learners' achievement of program implementation results. Results showed that using this tool significantly enhanced students' self-efficacy (16).

Furthermore, a survey conducted from 2013 to 2014 among 40 students enrolled in an Android development course indicated that practicing with MIT App Inventor was not only highly positive for beginners but also beneficial for more advanced individuals. Studies have demonstrated that this tool can support advanced computational concepts in teaching (17).

Using MIT App Inventor to design specialized educational courses significantly reduces errors resulting from the perception of technology experts and course subject matter specialists. It significantly contributes to familiarizing subject matter specialists (teachers) with how to use technology in course production. This tool provides the necessary infrastructure for interaction between technology experts and subject matter specialists. Considering that perceptual errors in healthcare can impact patient health, a study was conducted to develop a healthcare application in pharmacy. MIT App Inventor, with its features of accessible design, ease of experimentation, and standard output production, facilitated active interactions between the information technology and pharmacy groups, substantially reducing perceptual errors and enabling learning for both groups (18).

Implementation of TPACK-Based Educational Scenarios with MIT App Inventor

According to the TPACK model, each learning activity falls into one of the following seven categories (19):

- ***Attention Activity:*** In this method, students are required to find information on topics they are not familiar with.
- ***Exercise Activity:*** In this section, methods are suggested for practicing the skills and algorithms they have learned.
- ***Interpretation Activity:*** This section introduces methods for a complete understanding of formulas and concepts, emphasizing the importance of finding connections between concepts.

Table 1: Implementation of Learning Process-Related Scenarios in MIT App Inventor

Learning Activity	Scenario	Skill description	Example	How to implement in MIT APP Inventor
Application activity The skill of choosing a strategy.	A branch	It's about giving learners a series of decision points and then guiding them down different paths based on their choices. The goal is to create a more personalized learning experience that fits each learner's needs.	An educational application is created for the clinical medicine course. The user is asked to select the options to determine "Which is the best way to investigate the effect of drinking water on human health?" Users are then presented with different choices, such as "do a study to test a hypothesis" or "do a survey to collect data". Based on their choices, they are presented with different results and feedback. This application helps the users enter different pages depending on the answer to continue the learning process.	**User interface** Use the "Label" tool to display the questions and the "Radio Button" for the answer options. ● Add a "Button" with the text "Check Answer" to check the user's answer. ● Add answer options for each question. Define a page for each option. **Behaviors** For each "Check answer" button: ● Check the user's answer with the defined conditions. ● Using the conditional control block "IF" based on the value of the selected answer, be redirected to the dedicated page of that answer. ● Create different branches based on the answer result.
Interpretation activity The skill of listing the topic and the main points of the content (categorizing).	drag and drop	Learners are presented with a set of draggable items and a drop zone where they must place the items in the correct order or group them into categories.	An educational application for drug combinations and drug interactions is developed. Users can select different drugs and see what interactions may occur between them.	**User interface** From the "Designer" menu, create the required user interface elements. For example, use "ListPicker" to select drugs and "Label" to display results. ● Use drag-and-drop elements such as "Horizontal Arrangement" and "Vertical Arrangement" to create different parts of the user interface. **Behavior** When the user selects and drops a drug: ● Get the selected drug information. ● Get possible drug interactions from a database or information table according to drug selection. ● Display the results of drug interactions on the label.

Learning Activity	Scenario	Skill description	Example	How to implement in MIT APP Inventor
Application activity	Interactive slide	It includes various multimedia content, including text, images, videos, and interactive elements such as quizzes, surveys, and simulations. This type of interaction with content through activities and assessments enhances the learning process by promoting critical thinking and information retention.	Survey or test application to interact with the user by asking questions and receiving answers from the user and displaying the results.	**User interface** ● For each question, add a Label to display the question. ● For each answer option, use the Checkbox or Radio Button and put the option's text in the corresponding Label. **Behavior** Set the click event for the button where responses should be recorded. ● Use "IF" and "IF Else" control blocks to store and process responses. ● You can save the test results in the application's temporary database or send them to an external database.
Production activity The skill of producing a presentation	Interactive chart	Interactive graphs enable learners to explore data sets and gain insights through exploration, analysis, and interpretation.	Building an interactive graph application that generates graphs from data.	User Interface ● Create your application's user interface using various components. You can use components like a Button (to create the chart), a Label (to display the chart name), and a Canvas (to display the chart). Behavior ● Set the click event for the button where the chart should be generated. ● Using blocks, analyze your data and make the corresponding graph. ● You can set labels and chart names for the X and Y axis charts. ● Improve and develop your application by adding more features, increasing data, types of charts and other features. ● If you need the chart results for future use, you can save them in the app's temporary database or send them to an external database.

- ***Production Activity:*** This section outlines methods to empower students not only as consumers of ready-made content but also as contributors who can teach new concepts and materials themselves.
- ***Application Activity:*** This section presents techniques for connecting learned concepts and a real-world problem that technology can address.
- ***Evaluation Activity:*** This section discusses methods for evaluating a task, such as evaluating one›s work or assessing another person›s work. This approach helps students better understand the concepts.
- ***Creation Activity:*** This section discusses how individuals are actively engaged with course concepts and methods for generating ideas.

Table 1 provides a summary of activities, skills, and scenarios related to the learning process and how to implement them in MIT App Inventor.

Conclusion

Utilizing MIT App Inventor in the education process can enhance interaction and adaptability and foster critical thinking and calculation skills. Key advantages of this platform include its user-friendly interface for building Android applications, being free and open-source, and supporting a broad range of capabilities such as multimedia components and connectivity to web services. Additionally, it boasts a large and active community of users and developers dedicated to solving problems and providing assistance.

Nevertheless, the platform has some drawbacks that the support team actively addresses. These include limited platform support, currently available only for Android devices, and challenges in checking and testing production applications. The learning curve may also be relatively steep, particularly for those without programming experience. Despite these disadvantages, ongoing efforts are being made to overcome these limitations, ensuring continuous improvement in program development.

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Authors' Contribution

All authors (DR and FM) were major contributors to writing the manuscript. DR and FM provided writing and critical revisions. All authors finally approved the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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