Introducing STEM Activities into Informatics Education through Mobile Apps Development

Zuzana Tkáčová[1,2] (orcid.org/0000-0002-9805-6242),
Ľubomír Šnajder[2] (orcid.org/0000-0002-8854-1009), and
Ján Guniš[2] (orcid.org/0000-0002-6027-7453)

[1] Faculty of Science, Pavol Jozef Šafárik University in Košice,
Košice, Slovakia
zuzana.tkacova1@upjs.sk, lubomir.snajder@upjs.sk, jan.gunis@upjs.sk
[2] Faculty of Education, Constantine the Philosopher University in Nitra,
Nitra, Slovakia
zuzana.tkacova@ukf.sk

Abstract. Mobile technologies provide a tremendous potential for creative and productive activities that are very beneficial in education. This paper presents the concept of mobile apps development as an emerging tool for informatics education enhancement through a constructivist approach with the focus on science, technology, engineering and maths (STEM) topics. In this paper we describe the methodological background of using MIT App Inventor as a valuable teaching tool for mobile apps development and four different STEM pupils' projects solving real-world problems: city traffic monitoring, pedometer, geolocation and working with sounds and speech.

Keywords: Mobile technologies, Mobile apps development, Programming · STEM, Project-based learning, MIT App Inventor

1 Introduction

Dynamic development in computer science brings new inspirations and ideas for innovation and enhancement of informatics curriculum through the introduction of modern interactive tools. Mobile technologies have become an essential part of everyday life of children. They are no longer used only for communication and quick access to information, but they provide a tremendous potential for creative and productive activities that are very beneficial in education. An increasing number of initiatives from different countries focus on implementing mobile apps development into existing or new curricula [1]. An important role in this process is played by MIT App Inventor [2] – a visual, cloud-based blocks development environment for building Android apps that is being widely used in classroom all over the world and since its introduction in 2009, the community of users exceeded 6 millions coming from almost 200 countries. Besides programming just as with a textual language, the valuable MIT App Inventor´s capabilities include access to most of the tablet´s and smartphone´s functionality (i.e. smartphone calls, SMS texting, sensors for location, orientation and

acceleration, text-to-speech and speech recognition, sound and video player´s features), the ability to invoke other apps with the ActivityStarter component, database access (both on the device and on the web), as well as access to web information sources (APIs) that enable work with data from Facebook, Amazon, etc. [3]. All of these features provide the foundation for many different advanced apps (i.e. games, social apps, quizzes, etc.) in connection with the idea of STEM (Science, Technology, Engineering and Maths). Thus the mobile apps development brings many opportunities for students to explore areas such as multi-touch user interfaces, GPS location services and social media [4]. Although ICT-based STEM pedagogy has a positive impact on pupils' motivation, STEM programming activities are not common in typical school programming tasks as observed in Slovak schools. When programming such applications, empirical data is obtained, algorithms are gradually being adjusted to match reality (e.g. counting number of steps from accelerometer data records). Thus we strive to develop the capabilities of scientific work, critical thinking, computational thinking for all, not only gifted pupils, and also to give further meaning to programming as a useful practical skill for solving real-world problems.

In the following sections, we present a brief methodological background of using MIT App Inventor, and provide some insight into a set of simple STEM programming activities suitable for upper secondary school informatics classroom (age 15-18).

2 Methodological background of using MIT App Inventor for STEM education

Utilizing STEM gives students the foundation to help them cultivate necessary 21st century skills — creativity and innovation, critical thinking and problem solving, communication and collaboration. As showed by Knobelsdorf and Romeike [5], since the process of producing meaningful artifacts (e.g. based on "real life" projects that are essential for STEM) is being percieved as creative, a bigger emphasis on creativity in informatics classooms is needed in order not to bore and lose more creative or female students [6]. When focusing on students new to programming, it was found that MIT App Inventor as a visual language represents a positive way to introduce students to problem solving and computational issues [7] - as observed, after students became familiar with its components and events, they were more prepared to learn advanced textual languages like Java.

Through his website The Course in a Box [8], David Wolber recommends the Build—Conceptualize—Customize—Create model for teaching the MIT App Inventor programming. At first, pupils build an interesting app, using a step-by-step tutorial. Next, they discuss conceptual questions about the app in small groups and later as a class. Then, pupils add interesting features to the app. Finally, after two or three iterations of the Build—Conceptualize—Customize process, pupils should be ready to program their own apps of personal interest to

them. Recently, we introduced also several inquiry-based approaches in teaching of mobile app development [9] inspired by David Wolber´s model [3].

3 STEM programming activities in MIT App Inventor

In this section we present four typical STEM representative apps that have been succesfully tried out in our teaching practice and with regard of benefits of STEM (mentioned in the previous section) we recommand them for implementation into informatics classrooms. First application, we use device mobility (smartphone, tablet) to collect field data on transport. This application is only a part of the entire data processing process. The data is stored (locally and on the server) in the CSV format for further processing. Second application uses a mobile sensor (accelerometer) to record speed changes. Based on the analysis of these changes, we have developed an algorithm with our students by which the number of past steps can be calculated (based on physics and mathematics). In the third application (a speaking compass), sensors (orientation, localization) are used to determine the position and the distance and synthesis of speech is used for the audio output of the current position. The fourth STEM app extends to arts (known as STEAM) and is a simple, yet creative music app for kids to learn the sounds of individual musical instruments.

3.1 Data logger for the city traffic

This activity was designed as a demonstration of how to use mobile devices for data collection with the focus on traffic density near the school [10]. Pupils work on a STEM project consisting of a programming problem (how to create a mobile app for measuring and collecting data) and a scientific problem (how to process and analyze data and thus improve the city traffic). From a programmer´s point of view, the interface should be based on a set of input buttons determining both the direction and the type of transport and a control buttons (undo, reset and exit). The program code uses Location Sensor, handling of buttons and a new procedure (write_data) for writing data to a CSV file (together with the current time, actual latitude and longitude).

3.2 Pedometer or physical activities counter

This activity focuses on developing a mobile app that will record the number of travelled footsteps, (i.e. pedometer), a STEM project involving physics and technology (what physical quantities are measured by sensors), programming (how to detect, save and visualize values of the sensors), mathematics (how to calculate the number of walking steps), as well as biology (which physical activities and in which way contribute to one´s health improvement) [10]. The user interface consists of a START/STOP button, labels for displaying the number of footsteps and immediate acceleration, a slider for the sensitivity threshold

setting and an EXIT button. The programming code uses an acceleration sensor and a timer. Measured data is recorded to a CSV file, which can be further processed and evaluated in various tools. Using this app, pupils can investigate different types of walking and different placements of the mobile device on their bodies.

3.3 Geographical apps

MIT App Inventor offers various possibilities how to connect geography with programming through the orientation and location sensors and the ability to work with Google Maps, e.g. the map tour or car location app [3]. More advanced projects on virtual expeditions may involve as well the Google Cardboard SDK to add virtuality to MIT App Inventor [11].

We prepared a teaching module on how to create an app for visually impaired that, in addition to showing the azimuth and the cardinal (semi)directions on the compass, will be saying the current cardinal direction with the synthetic voice (i.e. the TextToSpeech component).

Another real-world based task is to create a mobile app that allows saving the GPS position of the location and then return to it later by computing the distance and direction from the current GPS position to the stored GPS position. This app includes also the TinyDB component to store the values of latitude and longitude.

3.4 Apps working with music, sound and speech

Integrating the arts and creativity with STEM (what is known as STEAM) allows pupils talented in other domains than maths and science to use different ways to engage in, develop and showcase their skills [12]. An example of incorporating the arts into STEM project is a virtual xylophone app [3], where the user can play eight different notes by touching coloured buttons on the screen, press a PLAY button to replay the notes and press a RESET button to enter a new song. Together with our pupils, we designed an education app for smaller children to present and to teach musical instruments (pictures, sound and a little bit of theory) using the Sound, TextToSpeech and SpeechRecognition components, thus the user can interact with the app by clicking the pictures or by saying the name of the instrument. This project demonstrates how to integrate the media files (i.e. graphics or audio) into the mobile app in a creative way. Further improvements might include also video files and web content access using the WebViewer component.

3.5 Other project ideas

There are many more different cross-curricular STEM project ideas involving MIT App Inventor. We propose a collaborative project on electronic herbarium might use the Camera, LocationSensor and Third Party Application (ActivityStarter) to capture the plant, record its location, time (i.e. season) and title (or a

short description) directly on an online map. From the collected data, it is possible to assemble the plant atlas. The concept of the electronic herbarium can be easily transformed into a collector of interesting objects or monuments in a city (e.g. geographical or historical scope). Augmented reality can be incorporated into mobile apps development through QR codes – pupils can create an app for an interactive exhibition that scans QR codes to get further information (i.e. video, audio recording, quiz questions). Interesting apps promoting health and a healthy lifestyle might cover for instance a cookbook of healthy dishes with nutrition information or an emergency app for elderly people - when a fall is registered, the app sends an SMS to the selected mobile number together with a GPS position of the fall.More technology-related robotic STEM projects can be based on LEGO Mindstorms NXT or EV3 components [13, 14]. MIT App Inventor offers LEGO components (motors and sensors) access through its component palette. As for the communication with LEGO brick, BluetoothClient component is used.Recently, the release of a new expansion to MIT App Inventor has been announced. This expansion will allow to design, create, and interact with the Internet of Things (IoT). Thus pupils can interact with the physical world and the Internet, develop IoT applications the same way as any other MIT App Inventor mobile apps and incorporate smartphone capabilities into their IoT projects [15].

4 Conclusions

Over the last few years, we have begun implementing the programming of mobile apps into computer science lessons. In order to support the effective integration of mobile apps programming into education, we have implemented several MIT App Inventor programming trainings for Slovak IT teachers. We also deal with the issue of mobile apps programming in courses for future teachers. In the framework of the national project "IT Academy - education for 21st century" [16], we develop methodologies and learning texts for the programming of mobile apps for partner Slovak upper secondary schools. Based on our experiences so far, it has been shown that the use of project-based learning of mobile apps development supports the motivation and engagement of pupils. That is why we have started to offer short-term workshops also for non-technical secondary school pupils (e.g. health care professionals), where programming of STEM applications plays an important role in facilitating the interconnection of informatics and vocational education.

Programming in MIT App Inventor is a very attractive, dynamically evolving cross-curricular topic. We mentioned several examples and best practices of how to effectively and meaningfully integrate both STEM/STEAM and mobile apps development into the informatics classroom. Through solving real-world problems, these project-based activities can develop additional competencies of pupils, such as inquiry skills, complex thinking ability, technological literacy or creativity.

5 Acknowledgements

This article was created in the framework of the National project IT Academy – Education for the 21st Century [16], which is supported by the European Social Fund and the European Regional Development Fund in the framework of the Operational Programme Human Resources.

References

1. Curriculum | Explore MIT App Inventor, http://appinventor.mit.edu/explore/resource-type/curriculum.html.
2. Massachusetts Institute of Technology: MIT App Inventor 2. http://ai2.appinventor.mit.edu/
3. Wolber, D., Abelson, H., Spertus, E., Looney, L.: App Inventor 2: Create Your Own Android Apps. O'Reilly Media. (2014).
4. Duran, M., Höft , M., Medjahed, B., Lawson, D.B., Orady, E.A.: STEM Learning: IT Integration and Collaborative Strategies. Springer. (2016).
5. Knobelsdorf, M., Romeike, R.: Creativity as a pathway to computer science. In: Proceedings of the 13th annual conference on Innovation and technology in computer science education (ITiCSE '08). pp. 286-290. ACM, New York, NY, USA (2008).
6. Romeike, R.: Applying creativity in CS high school education: criteria, teaching example and evaluation. In: Proceedings of the Seventh Baltic Sea Conference on Computing Education Research - Volume 88 (Koli Calling '07), Vol. 88. pp. 87-96. Australian Computer Society, Inc., Darlinghurst, Australia, Australia. (2007).
7. Wagner, A., Gray, J., Corley, J., Wolber, D.: Using app inventor in a K-12 summer camp. In: Proceeding of the 44th ACM technical symposium on Computer science education (SIGCSE '13). pp. 621-626. ACM, New York, NY, USA (2013).
8. The App Inventor Course-in-a-Box. http://www.appinventor.org/content/CourseInABox/Intro/courseinabox
9. Šnajder, Ľ.: Metodika výučby programovania mobilných zariadení. In: DidInfo 2015, pp 18–27. Univerzita Mateja Bela, Banská Bystrica, Slovakia (2015).
10. Šnajder, Ľ., Guniš, J.: The inquiry based approach in learning of mobile applications programming. In: Information and Communication Technologies in Education. pp. 211–221. University of Ostrava, Ostrava, Czech Republic (2015).
11. Shulmelchyk, K.: Experiments with Virtual Reality and MIT App Inventor. , http://ai2.appinventor.mit.edu/reference/other/vr.html (2016).
12. Miller, R.: Integrating the Arts and Creativity in STEM Education: Emerging Talent Using STEAM. In: Talieferro, R. (ed.) STEM education for high-ability learners: designing and implementing programming. pp. 207—223. Prufrock Press, Waco, TX (2016).
13. LEGO® MINDSTORMS® | Explore MIT App Inventor, http://appinventor.mit.edu/explore/content/legomindstorms.html.
14. Create apps for NXT with MIT App Inventor, http://www.legoengineering.com/create-apps-for-nxt-with-mit-app-inventor/.
15. Internet of Things, http://iot.appinventor.mit.edu/.
16. Itakademia, http://itakademia.sk/sk/domov/.