Learning Activities Mediated by Mobile Technology: Best Practices for Informatics Education

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Abstract: Mobile devices with all their advanced features (the networking and multimedia capabilities, portability, intuitive interfaces, location awareness etc.) enable teachers to involve students in learning activities that may bring the formal school environment closer to real-world contexts, provide the attractive and personalized learning experiences as well as enhance the collaboration, creativity and productivity of learners substantially. Thanks to the long-term national projects concerned with mobile technology and its successful adaption as an effective learning tool, teaching practice in Slovak primary and secondary schools is getting better. However, the integration of tablets and smartphones is still rather intuitive or even improper. Within the informatics education, lessons usually take place in a computer laboratory, so the innovative mobile scenarios are considered less frequently. This paper provides an overview of the potential of tablet devices to support learning. This paper presents the sum of general and specific use cases targeting the learning objectives stated by the Informatics curriculum. They were implemented during the regular lessons, non-formal workshops or summer camps and comprise both, the indoor and outdoor scenarios. They focus on informatics concepts and were designed to foster computational thinking. Mobile technology is used to facilitate the active construction of knowledge and development of new skills.

1 INTRODUCTION

Nowadays, mobile technology literally penetrates both, private and work spaces of many individuals as it impacts on ways they communicate, solve problems and even spend their free time. It is mainly their portability, the advanced networking and multimedia capabilities together with the intuitive interfaces and context-awareness that make the mobile devices so popular. Emerging technologies are in some countries becoming pervasive (Commission E, 2013). Present-day students use various mobile devices (cell phones, PDAs, smartphones, tablets) on a daily basis and with confidence, typically for connecting with family and friends, browsing the web, capturing and sharing moments and ideas, listening to music or playing games. Nevertheless, to become a successful lifetime learner, every pupil should experience the emerging technologies also as an effective learning tool; enhanced through collaboration (Haßler, 2015). The educational research in mobile learning is rather diverse (Cheung and Hew, 2009; Sharples et al., 2009, Johnson et al. 2014, Naismith et al., 2004; Kearney et al., 2012); in general, comprising anything relevant to the process of learning that is mediated by a mobile device (ranging from pure e-learning scenarios innovative classroom-based activities, to non-formal and informal learning situations). As pointed out in (Naismith et al., 2004), mobile technology provides an opportunity for a fundamental change in education away from occasional use of a computer in a laboratory towards more embedded use in the classroom and beyond. Being mobile adds a new dimension to the activities that can be supported, both because of the personal and portable nature of the devices themselves, and because of the kinds of interactions they can support with other learners and the environment. In (Kearney et al., 2012), the authors highlight three features of mobile learning: the authenticity, collaboration, and personalization:

- Authentic learning has great potential to increase the motivation and engagement of students. Using tools that are familiar to students from outside the school brings learning scenarios closer to the real-world practice. To make the learning authentic,

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students should apply the technology constructively and in a creative way (while solving problems, working on projects, performing experiments, exploring contexts and discovering meanings).

- Mobile devices and cloud computing support the collaborative activities that promote creativity, productivity and learning through social interaction. Data exchange and collaboration with other learners or teachers can happen in both, virtual and face-to-face settings.
- Personal nature of mobile devices enables the individualized learning experiences as they can be customized at a tool or a task level. This adaption to learners' specific preferences may also strengthen the feel of responsibility for their own work and learning outcomes.

The above-mentioned promises of using mobile technology for educational purposes correspond with the constructivist and constructionist learning theories our research and teaching approach is drawn on. In this paper, we suggest a conceptual framework for using mobile devices in formal educational contexts, namely the primary and secondary schools, with focus on the Informatics curriculum. Teachers in schools are expected to adopt the emerging technologies in a meaningful way (Johnson et al., 2014; Naismith et al., 2004). We strongly agree with (Sharples et al., 2009), that the design of mobile learning activities should be always driven by specific learning objectives. The use of technology is not the target but rather a means to enable activities that were otherwise not possible, or to increase the benefits for the learners. Mobile technologies may only be suitable for part of the activity, with other parts being better supported by other technologies, or by no technology at all. The examples of learning activities given in the following sections include indoor and outdoor scenarios that can be implemented within the compulsory Informatics lessons, as a non-formal activity in ICT clubs, during excursions or trips.

2 MOBILE TECHNOLOGY IN SLOVAK SCHOOLS

Conditions favorable to the process of integrating mobile technology with the actual teaching practice in Slovak schools have arisen thanks to the ongoing projects that are aimed at solving 3 problems:

- lack of modern equipments at schools; suggested solution is to provide schools with mobile devices (tablets),
- lack of modern materials and methodology, suggested solution is to prepare digital educational content for using on tablets,
- lack of m-learning practices of teachers; suggested solution is to train the in-service teachers for using mobile devices effectively within their instruction.

Highly digitally equipped schools, putting the focus on providing emerging technologies and interactive whiteboards, would help to overcome what is still considered by practitioners as the major obstacle to ICT use. The Survey findings concerning ICT infrastructure show that education systems are responsive to technological trends, for example implementing equipment policies reflecting recent trends in mobile devices. It seems that the priority is often to concentrate these efforts at first at secondary education level (Commission, E, 2013).

The DigiSchool (http://digiskola.sk/) project funded by European Union is implemented by Ministry of Education, Science, Research, and Sport of the Slovak Republic in cooperation with Methodology and Pedagogy Centre (institution for in-service teachers' education and training). One thousand classrooms in primary and secondary schools across the country were equipped with the Samsung technology (20 tablets with a 10.1" touchscreen and a stylus pen). Besides this technical aspect, also the initiative of digital content production is supported. These multimedia learning objects for various schools subjects are based on HTML5 and delivered to teachers through an online system. Teachers can attend specialized courses, download practical teaching guides or watch video tutorials.

The School at the Touch (http://www.skolanadotyk.sk) is a project of a non-profit organization called Edulab known also for their center of modern technologies (situated in Bratislava, the capital city of Slovakia). Edulab focuses their efforts on effective adopting of ICT in schools and promotes the active using of digital learning resources within the instructional process. In cooperation with a commercial partner (Samsung), 12 schools were chosen as experimental for setting up a dedicated tablet classroom (with 20 tablets, an interactive board and the Samsung School as a professional classroom management solution).

The absent of a tablet policy, the lack of relevant training (Oliviera, 2014) and the lack of materials and methodology is often discussed when proposing the application of tablets in education (Švecová et

al., 2015). Therefore the Edulab is also responsible for organizing courses, demonstration lessons and conferences for teachers and takes care of the online environment for sharing experiences and creative ideas of participants (video blogs and learning materials produced by teachers, pupils' work etc.). The project has been extended to the field of prospective teachers' education in January 2015. Three Slovak universities (including the authors' home university) with long tradition in teacher training programs were also provided with tablet classrooms. This university part of the project is meant for developing effective strategies of using the touchscreen technology within the pre-service teachers' curriculum.

To reveal more about the actual situation in schools, we pursued a survey and gained responds from 140 primary and secondary school teachers. We were interested in mobile devices their schools are equipped with as well as whether they really use them to enhance the learning process. Fig. 1 shows the results: "Tablets" was the prevailing answer (45%), 13% of schools declared having voting devices. However, according to this survey, only about a half of the total number of mobile devices present at schools were being actively used. The smartphones seem to be an exception as teachers reported their usage, though they were not in the possession of schools. This means pupils can use their personal devices what is in compliance with the popular BYOD (Bring Your Own Device) policy.

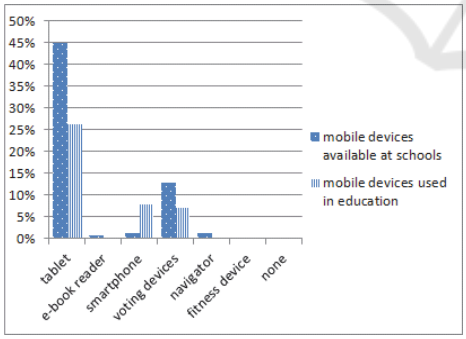

Figure 1: Survey results: The percentage of responses to questions "What kind of mobile devices are available at your school?" and "What kind of mobile devices do you use in education?".

The second group of questions was concerned with determining more about the learning activities carried out during lessons. The survey's results (Fig. 2) indicated that the science and foreign language teachers are those who are the most active users of mobile technology. Surprisingly, only 21% of Informatics teachers affirmed the using of mobile technology in their lessons. The same results are declared by other researchers (Švecová et al., 2015); tablets are used by only 2% of Informatics teacher in science oriented and 0% of teacher in humanities oriented grammar school.

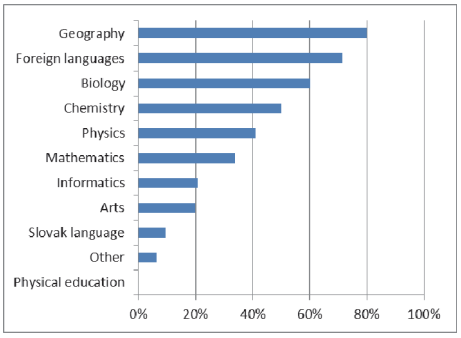

Figure 2: Survey results: The use of mobile devices in particular school subjects.

While analyzing the data about typical learning activities, 3 categories of answers were identified: content consuming (electronic textbooks, presentations, web), using tools (electronic communication, numerical calculations, note taking, testing), and creating (getting and processing of data, programming). In answers, the active methods (using tools, creating) dominated the passive digital content consuming.

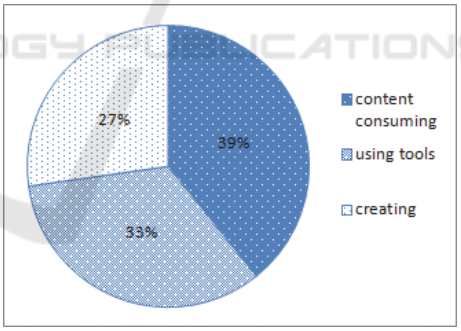

Figure 3: Survey results: The categorization of responses according to ways of using mobile devices in education.

The outcomes of the survey suggested some important conclusions:

• In many schools, tablets are present. However, the number of schools reporting their active using is much lower. This may come from the fact, that teachers need to get familiar with the new technology first.

• Teachers from the survey prefer active methods of working with mobile devices. Still we consider the high ratio of passive content-consuming activities (39%) inappropriate. This fact is in

contrast with all modern trends in education emphasizing the constructive learning strategies.

• The Informatics teachers do not use mobile devices very often, probably because the instruction takes place in a computer classroom where students usually work on desktops and don't need to use another computing device.

3 TABLETS AND SMARTPHONES IN INFORMATICS EDUCATION

The national projects in Slovakia are focusing on tablets as they have larger screens and are more powerful in general than smaller hand-held devices. However, in some situations (e. g. during an outdoor game, a museum visit or a school trip) also the smartphones and tourist navigators may be sufficient or even more suitable choices.

In Table 1, we analyze strengths, weaknesses, opportunities, and threats involved in using tablets and smartphones in education.

Based on the SWOT analysis, we identify the key features that make tablet technology useful for Informatics education besides standard computers:

- *Portability*. Tablets are wireless computing devices, which may be used in education anywhere, outside the computer classroom, and even outside the school building. They enable more flexible, decentralized learning, not limited by restricted space of computer classroom.
- *Touchscreen technology* allows students to interface with tablet computers in more natural and immediate manner. Touching the screen means much more direct interaction with a computer than using a traditional input device like keyboard and mouse. Therefore, the touchscreen technology makes computers accessible for younger children who are still developing their motor skills, and opens new possibilities in learning with technology for older students too, e.g. with handwriting, note taking.
- *Sensors.* Tablets have built-in sensors for gathering various types of digital data: camera for capturing photos and videos, microphone for voice recording, GPS receiver for determining the geographic location. Learning about digital data processing is more attractive to students when they work with their own data gained from tablet sensors.

Table 1: A SWOT analysis of tablets in education.

Strengths:	**Weaknesses:**
portability, size, weight wireless connectivity touchscreen technology sensors multimedia, quick start	battery life small display low display readability outdoors software keyboard
Opportunities:	**Threats:**
decentralization of learning: using tablets anywhere, anytime interfacing in more natural, immediate manner new ways of using: handwriting, drawing, recording data, listening audio, watching video collaborative learning cloud computing	technical problems with Wi-Fi connection, charging battery non-qualified teachers wrong teaching methodology focused on content consuming distraction from work

3.1 Using Tablets as Versatile Personal Learning Tools

Tablets have strong potential to change to an attractive learning tool in the hands of pupils. The teachers should guide them with proper tasks, but not trying to make tablets a universal solution in every situation. According our experiences during lessons and informal acitivities, we recommend teachers to apply the blended teaching strategy and vary the learning activities reasonably.

With help of a classroom management system, the distribution of assignments and other digital resources to tablets as well as storing and sharing of pupils' solutions in cloud repositories are easy. To avoid the danger of distraction from learning objectives, teachers can centrally manage the content and functions of pupils' devices, block the unwanted activities (e. g. playing games during lessons), broadcast anyone's screen in public and so focus the attention of the class as needed.

The distinctive features of tablets discussed in previous chapters suggest some of the meaningful use cases:

Tablets have software keyboards, but most of them accept also the handwritten input. Pupils work with all kinds of digital learning resources on tablets in rather natural way, e. g. interact with textbooks/worksheets by adding personal notes (Mang and Wardley, 2012) or producing handwritten solutions with graphical tools provided by tablet's applications. When writing personal notes, preparing a project report, documenting an experiment or a problem's solution (e. g. using the popular S Note or Evernote applications), pupils can easily combine various media elements to create highly attractive outputs. Photos, videos or sounds

taken during lessons can be immediately used (without post-production) and inserted into the digital document that pupils are working on.

Tablets integrate many hardware and software tools into a compact portable unit. The online stores offer lots of simple and intuitive applications usable for educational purposes (e. g. games, data recorders and analyzers, creative environments). In our workshops and during summer camps, we used the mobile applications e. g. for creating anaglyphs (3D photos taken outdoors), multimedia presentations, collages and animations (authors). For interdisciplinary projects, the data gathering functionalities of tablets are of a great benefit. Various attributes of the environment can be measured with sensors or specialized mobile applications and stored while moving in a terrain. Pupils could realize a survey or examine some phenomenon within a scientific project. The calculations or other forms of post-processing tasks may be finished later, e. g. at home or in a computer classroom.

3.2 Playing Location-based Games

Since hand-held devices are capable of identifying the user's location while she/he is moving in a terrain, it is possible to develop and play mobile computer games that process the geospatial data as an essential input. When players are required to physically move from one place to another in order to progress, the game is considered to be location-based. In our case studies (Lovászová and Palmárová, 2013; Palmárová and Lovászová 2012), several examples of outdoor learning activities inspired by well-known LBGs (Geocaching, Wherigo and GPS Drawing) were given. Playing LBGs with pupils was found beneficial from different reasons. The informal and competitive atmosphere of a game strengthens the motivation of pupils to participate actively and promotes the authentic learning. Educational LBGs (when properly designed) let pupils learn constructively by problem solving and performing experiments, individually or in collaboration within teams. Health and social aspects of playing outdoors with fellows should not be omitted as well.

3.2.1 Hide-and-Seek Activities

Geocaching is world-wide hide-and-seek game popular thanks to the analogy with searching for a real treasure. Players (geocachers) navigate to a specific set of GPS coordinates and then attempt to find a geocache (container) hidden at that location. Geographical coordinates of caches and their descriptions are published online (https://www.geocaching.com/). Caches are founded by volunteers, usually on places that are interesting to visit (cultural sights, historical monuments, beauties of nature etc.). The container usually contains a logbook, a pencil and some souvenirs. After discovering the cache, players are obliged to sign the logbook and after returning home, they log their experience online to share their success or failure with members of the geocaching community. In (Palmárová and Lovászová, 2012), we suggested a learning scenario that enables pupils learn fundamentals of GPS technology by using it in action. While collecting series of hints needed to calculate the final location of a hidden container, pupils encountered various types of problems connected with the Informatics curriculum. In order to solve them quickly, pupils were expected to collaborate. Geocaching may be also a theme of an interdisciplinary project (e. g. pupils can found and maintain their own thematic caches or watch and analyse routes of their travelling bugs).

The locations and hiding tricks are what give geocaching hunter feels on a geocache quest. But what if instead of following the coordinates, we just followed distance prompts? The Reverse Geocache Puzzle is a sort of the game that use an Arduino-based puzzle box that won't open until it is taken to a certain location (Hart, 2015). Instead of solid quest box we could use GPS navigation in mobile devices. The teacher set up the coordinates of final destination and is the only one person who knows the coordinates.

Figure 4: Triangulation created during ICT-oriented summer camp.

He/she only answer to players the distance like "you are 2 km from the target". Backwards geocaching is a game where players need to triangulate (Fig. 4) the "magic spot" by using a map, scale and compasses.

3.2.2 Augmented Reality Games

Augmented reality location-based games are computer games situated in the real world combining physical environment with additional digital information supplied to player by mobile location-aware device. An example of software platform for developing such type of games is Wherigo.

Typical Wherigo games offer a sightseeing tour or a fictional adventure (based on fairy tales, some sport activities, board games, true stories etc.). Players have to visit specific places (called zones), they fulfil tasks, find, collect and use virtual or even real objects. To play a Wherigo game, a Wherigo cartridge has to be downloaded and the Wherigo Player application must be installed into some GPS-enabled device. Wherigo cartridges are created (programmed) by volunteers from the geocaching community and published on the dedicated portal (http://www.wherigo.com/). Most of these games were built primarily for entertainment. However, the emphasis on some educational aspects of the games may result also in non-formal or informal learning. In (Lovászová and Palmárová, 2013), Wherigo games where used to introduce pupils to the concept of a stack data structure (by simulating a procedure calls while carrying out a chain of missions) and discovering the necessary condition for the existence of Eulerian cycles in graphs (by visiting zones/vertices of a virtual image in a specific order).

3.2.3 GPS Drawing

GPS drawing combines art, physical activity and digital technology to create large-scale pictures by recording a walking route using GPS. Location-aware device is used as a pen led by the user who walks on the land as on a large canvas. Walking is carried out mostly in open spaces like playing fields, parks, or in an urban environment along footpaths, roads. It can be guided by a sketch of the picture in a ma (Fig. 5) or navigated by instructions so that walkers don't know what they are drawing in advance. GPS drawing activities can be based on creating individual designs as well as on creating collaborative compositions combined from several tracks (Woods, 2014). Some examples of GPS drawings created on workshops organized by the paper's authors are shown in Fig. 5.

Data collected during the walk provide interesting information: about the time of visit, latitude, longitude, and altitude of particular track points on the route. These data are usually recorded

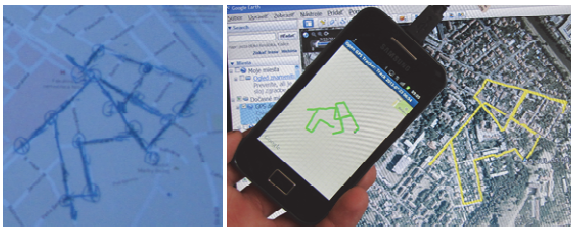

Figure 5: GPS drawings created during workshops and ICT-oriented summer camps.

into a text file using a mark-up language which is both, human and machine readable (e.g. GPX, KML). Data can be processed by students during Informatics lessons at different levels of difficulty: from simple visualization of their route using specialized mapping software (e.g. Google Earth) to more in depth projects that focus on the technical aspects of working with geographic data using some general-purpose application software (e.g. spreadsheets).

3.3 Programming Mobile Application

Educational programming is considered to be an essential component of the Informatics curriculum. When smartphones and tablets are chosen as the target platform, it is likely to enhance motivation and engagement of students significantly. Students are put in a role of creative developers. They produce solutions that can be run on their personal mobile devices. In this way, also the project assignments could be better linked to what pupils experience in their everyday lives.

The professional development tools are too complex and so not suitable for using in primary and secondary schools. The programming environments designed specifically for children and non-programmers should be used instead as they possess the beneficial attributes of educational software. The MIT App Inventor and the Urwigo builder should be recommended as programming environments for developing mobile applications in school Informatics. The MIT App Inventor is an online tool that runs within a web browser. The Urwigo builder is a standalone application for programming location-based games. Both of them are based on visual languages, ready-made components and event-driven programming. In both cases, pupils are able to share their products in public within the related online communities (http://gallery.appinventor.mit.edu, http://www.wherigo.com).

3.4 Real-time Questioning

Tablets and smartphones can be used as devices for transmitting responses to teacher's questions posed in a face-to-face setting. With support of a student response system (SRS), automatic recording and real-time processing of responses enable teacher to use the immediate feedback (gained from the whole class) also for purposes of the formative assessment. The responses can be anonymous; the results can be visualized for students as well as stored for future analysis. The SRS learning activities are likely to:

- facilitate the maintaining of student attention,
- encourage students' activity during lessons,
- support collaborative learning,
- stimulate critical thinking and creativity,
- assist teachers in assessing students' level of comprehension.

In Table 2, we recommend general strategies for effective implementation of the SRS-based learning activities that are suitable also for the Informatics lessons. These strategies are grounded in verified suggestions published in (Mendez-Coca and Slisko, J., 2013; Dervan, 2014; Liu and Taylor, 2013) as well as our own positive experiences with the Socrative SRS (http://www.socrative.com) - a high-quality web-based system using the existing Wi-Fi or wired networks with standard mobile or desktop computing devices as transmitters.

Table 2: Strategies for using student response systems.

Category	Goals	Educational activity
test	to automate student assessment	summative or formative assessment tests; knowledge quizzes
quick question	to stimulate student engagement, to gauge the level of student understanding	real-time question – immediate responses – projection of responses – discussion among students
collecting ideas	to support collaborative learning by sharing ideas	generating creative ideas in brainstorming; sharing different answers/solutions to divergent questions/problems
voting	to stimulate critical thinking	voting for the best idea in brainstorming; peer-assessment
survey	to determine students' attitudes, opinions	ice breaking questions/quizzes/surveys; self-evaluating surveys

3 CONCLUSIONS

One of the interesting findings of the study is that although the devices are present at school, they are not used very much. The ownership of these devices must be followed by m-learning practices by teachers. The long-term projects DigiSchool and School at the Touch were initiated by state institutions in order to improve the status quo of teaching practice in primary and secondary schools in Slovakia. Teachers who are actively involved in these projects appreciate the opportunity to learn how to adopt the emerging technologies to enrich their instruction with innovative learning activities. The first feedback coming from experimental schools and other participants is promising. In previous chapters, several ideas for using mobile technology in secondary education were presented. Some of them are applicable in general, in any of the traditional school subjects. In our research project (Mobile Technology in Schools for the 21st Century), we target specifically on the Informatics curriculum to overcome an objective lack of practical teaching guides that would be helpful for teachers of Informatics.

The suggested conceptual framework (Fig. 6) points out the main reasons for considering mobile learning scenarios more frequently: Tablets and smartphones have features that cannot be found on classical desktops (portability, touchscreen interface, various input sensors etc.). The mobility of these devices opens new possibilities for collaborative learning and creative projects including authentic learning activities that can be pursued out of the classroom environment. The personal nature of hand-held devices contributes to the intrinsic motivation of students and is likely to facilitate the active construction of knowledge or development of new skills. There are many learning objectives stated by the Informatics curriculum that may be reached when mobile devices are used in an appropriate way, always having the actual benefits for pupils in mind. We recommend to:

- use tablets or smartphones as personal learning tools that enable learners to be mobile (to search for information, create and share artifacts with classmates without being restricted by space or time, work with digital worksheets or compose multimedia solutions/reports/answers to problem assignments/projects/questions),
- involve pupils in outdoor learning activities (games or projects) that are connected with automatic or manual recording of data

(geospatial data, pictures, sounds, numbers or personal notes),

- let pupils program their own applications for mobile devices,
- use a student respond system for real time questioning during lessons and enhance the interactivity of learning by making use of the immediate feedback.

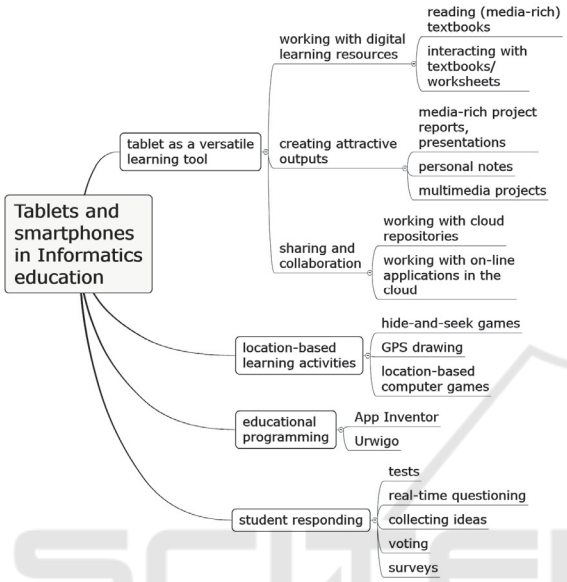

Figure 6: Tablets and smartphones within the Informatics.

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