Mobile phones in Education:
the case of mathematics

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Abstract:

This document examines the opportunity of using the cellular phone for educational purposes, specifically for teaching and learning mathematics. It probes how the attributes, abilities and functionality of the cellular phone can be successfully applied to and used in educational settings - thus bringing into consideration statistical data regarding usage and spread, cultural attitudes and needs, current functions and technological aspects. This document also describes a major research done so far regarding the use of the cellular in education, and gives directions for future research in this field. The picture that arises from the given data is of the cellular as a tool that opens up fascinating opportunities for education: an easily available tool that is already part of the culture and daily life of any teacher and student, and that is likely to become highly useful for both teachers and students given enough adequate applications are developed and provided the education community will latch on and explore how best to turn it into an integral and ubiquitous component of the learning environment.

Introduction:

Imagine the following scenario:

> You are a 16-year old student, sitting at a bus stop waiting for your bus to arrive. Trying to prepare for your upcoming Geometry exam you take out your cellular phone, open the installed mathematics m-Book and start learning—you review theorems and definitions while manipulating interactive diagrams, search the web to look for additional definitions, use geometry applets to explore concepts and test your understanding by doing some quizzes that your teacher stored in the class site for you to browse from the mobile device. You are already on your bus when your friend calls and asks for help with an exercise. You both then send a message attaching the module of the exercise each of you reviewed and compare the solving attempts. Now you feel ready to send the exercises to your teacher for her or him to check them. While busy doing all of the above, you've meanwhile reached home. Using your home PC you check your teacher's comments and continue your preparations there.

Sounds unreal? It shouldn't! The scenario is based on at least three realistic observations: (1) Technology plays an important role in learning and teaching because it promotes active learning. (2) Learning is a social-cultural process and teachers and peers are part of the individual cognitive process. (3) The talking function of mobile phone is no longer its dominant function and textual and visual communications as well as uses of web resources and applications (online and local) are fast becoming central functions of modern mobile communication.

Over the last two decades educational 'technologists' developed and studied uses of computers for teaching and learning in general and specifically for mathematics education[1]. While benefits become more obvious and results have encouraged some

[1] Some valuable online resources to learn about impact of innovative uses of technology in education and in mathematics education are: International Journal of Computers for Mathematical learning https://www.editorialmanager.com/ijco/ , Journal of Online Mathematics applications: http://www.joma.org/jsp/index.jsp , Association for the

important changes in leading education systems (e.g.; Australia, the Netherlands, Sweden and France are only a few countries where systems in which the use of graphic and symbolic software on PC or on handheld device are mandatory) availability is still an obstacle in major parts of the world for most teachers and students. Although desk computers are part of our daily culture, they are not portable and small enough to be a personal tool that each single student can use in school. Portable computers and PDAs are usually too expensive for use by all students. To address this problem a few leading makers, Casio and Texas Instrument (TI) among others, developed calculators providing specific applications for mathematics learning. The most widely used applications are graphic and symbolic calculators (known also as CAS – computer algebra systems), number calculators and some geometry applications. Along the trends of current education and the improved capabilities of hardware, calculator makers invest in making the personal tool to function also as a communication device in class (The TI navigator for example) and to provide customizing options to users by allowing downloading new applications from the web or computers. They also improve the hardware by providing larger screens, larger keyboards and advanced input and data collection devices (such as temperature or light probes). Obviously, such improved tools are far from cheap and require special investment for math class and reducing the chances of all school systems to benefit from it.

The development of new uses and new hardware for mobile phones seem to move in the opposite direction: Starting from an always available personal device for verbal communication, functions have been added to create uses that would soon turn the phone to be the ultimate general purpose handbag and personal computer. The education community has proved slow to explore the new reality that this device introduces. While there is still a lot to learn about uses of cellular phones for purposes other than phone calls, it becomes obvious that treating them only as a distraction to school and to the proper education is the wrong way to go (as we treated computers in school a generation ago). Mobile phones and **mobile learning** will allow students to learn anytime, anywhere and with any media. For example: the mobile phone already possesses the technological

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Advancement of Computing in Education (AACE) http://www.aace.org, , MAA digital library http://www.mathdl.org/jsp/index.jsp & the Math Forum http://mathforum.org/

options that the industry of calculators is now seeking for pedagogical reasons. Thus mobility, availability and flexibility are the keywords here.

Mobile phones are highly popular all over the world: for example - in Hong Kong, the mobile phone penetration rate is 98.2% as of August 2003, and analysts predict that by the end of 2004, every Hong Kong person will own one mobile phone on average (Wong et al, 2004); In the UK it is estimated that 81% of 11-15 year olds and 96% of 16-24 year olds have a mobile phone (Lubega et al, 2004). If we add to the above the fact that people spend more than 50% of their time outside their office or classroom (Hayes et al, 2004), it is only understandable why mobile phone companies are working hard to develop the "3G" (3rd generation) mobile phones that will enable users not only to talk but actually do almost everything they now do with their PC.

The mobile phone market develops rapidly: the global mobile commerce market will reach 200 billion dollars by 2004; there will be more than 1 billion wireless internet subscribers worldwide by 2005; multi-purpose handheld devices (PDA and mobile phones) will outsell laptop/desktop computers combined by 2005 (Hayes, 2004).

Besides its mobility, flexibility and availability, the mobile phone is also attractive because of its importance to teenage identity and friendship (Eldridge et al, 2001, at Attewell et al, 2003): Mobile phones are available and are part of the daily culture of almost every child.

The frequently offered content services offered on the cellular phone are:

- **Messaging:**
    - SMS (short messaging services – text only),
    - EMS (enhanced messaging service – simple animation and sound)
    - MMS (multimedia messaging services – unlimited messages that contain graphics, pictures, and video)
    - chat
    - POC (push to talk over the cellular) – direct connection without dialing, VoIP, Simplex connection.
- **Imaging:**

    - Picturing video, sharing video, watching video on “real time” (video download, video streaming, video phone, and video on demand).
- **Games:**
    - Local and online games.
    - Animation and 3D.
    - Multi users games
- **Business:**
    - Online PIM (personal information management).
    - Tailored information & content presentation for different user interfaces (WCSS).
    - Emails and internet services.
    - Wireless village solution:
        - Presence: information about the user’s location, availability, state, connection mode and more.
        - Instant messaging.
        - Grouping and group definitions.
        - Sharing of content in a shared database.
- **Media:**
    - Online information resources
    - TV and press online
    - Mob logging - Mobile ‘blogging’ websites offer an increasingly popular method for users to store & share their images by posting pictures, video and text from the mobile phone directly to the Internet , for free.

We therefore aim to probe how the availability of a common technology (not built for educational purposes) can become an effective part of learning and teaching and how mobile practices can have an impact on teaching and learning in general and specifically of mathematics?

How can we use the mobile phone as a smart mobile learning tool that students can use whenever and wherever they choose, at their own pace and preferences, for a great variety of mathematical applications?

Clearly, the potential for educational applications is huge: Students use updated educational applications on their phones, whenever it is convenient to them. They share their learning process and outcomes, without being in the same physical place (thus using emails, blogging, video streaming and MMS, internet browsing and many more) and they may get personal tailored exams and quizzes on their cellular phones. Teachers may benefit from online personal connection with their students' work and the worldwide resources they have access to

In the next section we will briefly review the technological aspects that enable the mobile phone to serve as a mobile learning tool.

Mobile Technology

General description:

Technologies used by mobile phones can be categorized in four groups (Hayes, 2004):

1. Media Player technologies
2. Copy protection technologies
3. Content transfer technologies
4. Content storage technologies

The media player technologies contain Web/Wap browsers, HTML browsers, Java Players, Flash player, Audio player, Movie player, e-Book readers.

The transfer technologies include:

- Connection via a mobile operator network (GPRS and 3G).
- Connection via local wireless network (wireless LAN, WiFi).
- Connection via Bluetooth or infrared
- Transfer via memory card

The storage technologies include internal memory and external memory like Compact Flash card, Memory Sticks, Secure Digital Cards, and Multimedia Cards etc.

All the above can be used for educational applications and purposes. For this specific research proposal, the most relevant technologies include the WAP\I-MODE and the J2ME:

WAP (Wireless Application Protocol)

A set of specifications, developed by the WAP Forum so that developers using Wireless Markup Language (WML) can build networked applications designed for handheld wireless devices. WAP design works within the constraints of theses devices (limited memory & CPU size, small screens, low bandwidth etc) (Mitchell et al, 2003). Today, every cellular phone has a WAP browser, and more and more Websites can be viewed by WAP browsers (Shmueli, 2004). Wap2.0, based on XHTML, will overcome the difficulties Wap1.0 still faces, such as the need for "light" websites for the cellular (only text or simple graphics). WAP2.0 will enable free design of cellular websites (full control of color levels, font type, output implications etc), will implement TCP\IP protocol (enables faster downloading of big files via the net, and more secure connections), and will actually make surfing the internet highly smooth and fully enjoyable (Shmueli, 2004).

I-MODE

I-MODE is the Japanese equivalent of the WAP. It is an example of the willingness of cellular users to use their cellular phones for almost everything: there are more than 40 million subscribers to I-Mode service, there are more than 70 thousands websites that are enabled via the cellular phones, and the amount of services enabled is enormous: bank transfer, ordering tickets for a great variety of services, paying bills and many more (Shmueli, 2004). We believe that countries in the west are heading up the same road, thus making the use of the cellular for educational purposes only natural.

J2ME (Java 2 Micro Edition) & Midlets

J2ME enables writing Java applications (Java Midlets) to cellular phones. The Java application will run in any environment, regardless of the OS, the Net or the type of cellular (Shmueli, 2004). Users can download new Java applications from many websites, whenever they want. They can run the application without being connected to the net. Java Midlets are specifically designed for and geared to the cellular phone, thus taking into consideration the environment limits (low CPU, low battery etc). All cellular companies integrate the J2ME technology as standard on every new phone.

Current Limitations and future solutions

The current generation of mobile devices is still limited by several inhibiting factors (Hayes, 2004). Nevertheless, current development runs at full speed to overcome those problems (Csete et al, 2004):

- Small screen size, which means small font size and lots of scrolling. The near future solution is a flexible film display that can be folded out when needed (PARC research, 2003, at Hayes et al, 2004).
- Non-ergonomic input method is another problem. The solutions might be voice recognition, projection keyboard, light pen and cursive hand writing recognition.
- The slow CPU speed problem can be overcome by a new breed of architecture for faster CPU.
- Limited memory will be solved by expansion of the memory card and increase of internal RAM capacity.
- Limited battery span is another problem. The solution is a new breed of lithium battery or using fuel cells in the cellular phones.
- Another major problem is the need for standardization of the operating systems. As is common in almost any technological development (e.g.; PC operating systems, video standards) the cellular companies and the software companies compete aggressively, vying to ensure its technology becomes the standard one. For now, the leading OS is Symbian (91% of the cellular phones are Symbian based).
- Connectivity bandwidth will be overcome by 3G mobile capacity (high-speed protocols GPRS & new traffic management protocol IPv6, WiMax).

In light of these complexities and the dynamic changes that both feed on and are shaped by the market demands, pilot research that will inform developers about needs, opportunities and obstacles seems extremely important at this stage.

Educational projects and research

The current educational research regarding the use of a mobile phone in an educational setting can be categorized into four major groups:

1. Survey studies that examine the attitudes of students towards m-learning.
2. Studies that examine **specific** educational applications on the cellular phone.
3. Studies that examine the uses of the **general, already existing** capabilities of the mobile phone for educational purposes.
4. Theoretical articles which give design guidelines and model specifications for educational development on the mobile phone.

This section will describe the variety of scopes and will exemplify the first three categories. The latter is beyond the scope of this paper, though its importance is of no doubt.

Survey studies:

Though raising some concerns, it can be claimed that, in general, students **are willing** to use their cellular phones for educational purposes:

Lubega et al (2004) conducted a survey among high-school students in the UK, regarding their attitudes towards mobile phones and learning. They found that most students felt positive about using the mobile phone for communication purposes (phone calls, SMS, MMS and emails) , specifically: group work, discussion, help offered to and from classmates, receipt of personalized information, communication with the teacher, issuing of spot quizzes.

Another attitude survey conducted among elementary kids in Japan (Inagaki et al, 2004), revealed that the kids tended to use the cellular phone as a tool for their learning, especially for communication purposes. In this research, the pupils were lent a mobile phone, with which they could take pictures and add comments to the school bulletin board, send emails, use the video phone and more.

A massive survey done by the m-learning project (see the following section for more details) asked young adults if they would use their phones for literacy and numeric

learning. Almost half of respondents express an interest in using phone based games to improve spelling, reading and math (Attewell et al, 2003).

Educational applications and uses on the mobile phone:

The line between **specific** educational applications and **general** uses of the mobile abilities for educational purposes is not always all that clear. This is due to the fact that the mobile phone is a multi application system, and as such, enables educational application to use other utilities of the cellular phone (for example: communication utilities). Thus, the cellular utilities can be seen as building blocks of the global educational application. An example is the **Mobile Author application** (Virvou, 2004), which helps teachers create and author their computerbased courses. It allows teachers to insert domain data into the application (lessons, assessment tests etc). The data documents are html documents. Both students and the teacher have access to the databases of the application, and they communicate with each other via SMS, email or the databases. All can be done via the mobile phone. Students can read their assignments, do their tests and send them to the teacher for him or her to check them. Throughout teachers stay informed of the progress of their students wherever they may be and whenever they want. Results show that the majority of teachers found the mobile facilities both useful and user friendly (especially those teachers without previous experience with computers).

Other **unique** educational projects are:

- the **m-learning project**: (http://www.m-learning.org/)
  This is a 3-year pan-European research and development study with partners in Italy, Sweden and the UK. The aim is to use portable technologies to provide literacy and numeric learning experiences for young adults (aged 16-24) who are not in a full-time education environment (Attewell et al, 2003). The m-learning project investigates how the technologies in the hands of these young people, now and in the near future, prompt them to engage them in learning activities, start to change their attitudes to learning and thereby contribute to improving their skills, opportunities and lives. This is an on-going project, in its very initial stage, yet its robustness and the involvement of LSDA (Learning and Skills Development Agency), university based research units (in Italy and in the UK)

and commercial companies as well, indicate that the combination of cellular phones and education is here to stay, its importance clearly recognized by researches and educational organizations as well as industrial companies.

- **Text2Teach project**:
  (http://www.unescobkk.org/education/ict/v2/detail.asp?id=11184). Text2Teach is the Philippine-based pilot of the Bridgeit program, a global ICT-based initiative by Nokia, the International Youth Foundation, Pearson, and the United Nations Development Programme, which aims to narrow the educational divide between nations by improving the quality of basic education in developing countries. It combines familiar mobile products and existing wireless technologies to deliver educational programs to teachers and students who otherwise would not have access to these materials. As a result, teachers anywhere in the world have the ability to select and receive digital educational programming – videos, pictures, text, or audio files – over mobile technology already in use in their community. The project aims to help improve the quality of teaching Science in Grades 5 and 6 through the provision of highly interactive easy-to-use multi-media packages designed to make science learning more exciting and meaningful among young learners.
- **E-viva project** (www.eviva.tv)
  a research project that aims to assess the potential of using the phone as a system for assessing students ("viva" stands for voice examination).
  The e-viva project is being funded by the Qualifications and Curriculum Authority and involves UltraLab and Orange. The project, in 10 schools across the UK, was launched last autumn term (2003) and involves 50-100 students at the key stage 3 ICT assessment stage.
  The student's voice will be converted by special software into text and moderators will use this to mark the viva. The final stage will involve posting students' coursework onto a website.
- **Mobile Learning project**
  (http://www.leonardo-ireland.com/leonardo2/proj.html#mobile_learning)

A European project, supported by the Leonardo Da Vinci program of the European Commission, which seeks to harness readily available mobile phones and their underlying technologies in the service of education and training. It will develop course materials for mobile phones, test and evaluate those course materials with cohorts of students and disseminate the results of the evaluations through public reports. The project is concerned not just with using current mobile phone technologies, but also with the new "smart phones" soon to be released. The Swedish mobile phone company Ericsson, a partner in the project, proposes to explore the development of learning content that takes advantage of voice-, Internet- and multimedia-enabled mobile phones – both phones that are on the market now as well as those that are coming soon.

Less robust examples, but not less important to our concern, are the educational games and Java applications that can be downloaded from many sites and are used on the mobile phone. This is an indicator of the willingness of cellular users to use their phones for learning. What is more, the more educational applications and games are proposed and used (even small applications of a very narrow and specific era), the more natural it becomes to think of the cellular phone as an educational tool. This leads straight to the use of the cellular phone for more professional applications as well. An example of sites that enable downloading educational applications is midlet.org .

Handheld technology in mathematics education:

The necessity of a handheld device for mathematical uses has been noticed over a decade ago. TI website (http://education.ti.com/educationportal) explains why the TI handheld mathematical PDA's offer solutions to many educational challenges such as:

- Enabling students to **independently** experiment and explore concepts as they are taught.
- Letting teachers set **different** difficulty levels appropriate to student's ability

- Limited investments in other graphing technology for classroom use
- Lack of students' motivation, overcome by technology which makes learning fun
- Provides "real time" examples that are relevant to students
- Helps establish discovery and exploratory skills in students, which is enabled by a personal device
- Enables teacher to see who has trouble with which mathematical concept at "real time"

Confirmation of the above indications can be found in the Ruthven review of calculators in the mathematics curriculum (1996) and in Savill-Smith et al (2003, at Attewell et al, 2003) who reviewed the published literature about the use of PDA's for learning. It was found that palmtop computers can:

- Assist student's motivation.
- Help organizational skills.
- Encourage a sense of responsibility.
- Help support both independent and collaborative learning.
- Act as reference tools.
- Track students' progress.
- Deliver assessment.

The same motivation surely stands for the cellular phones for mathematical uses.

Directions for future research

From the above descriptions of attitudes and uses of mobile phones in education, a picture arises of a tool that opens up fascinating opportunities for education: an easily available tool that is already part of the culture and daily life of any teacher and student, that can become useful for both teachers and students if appropriate applications will be developed and if the education community will latch on and explore how best to turn it into an integral and even leading component of the learning environment. As happened

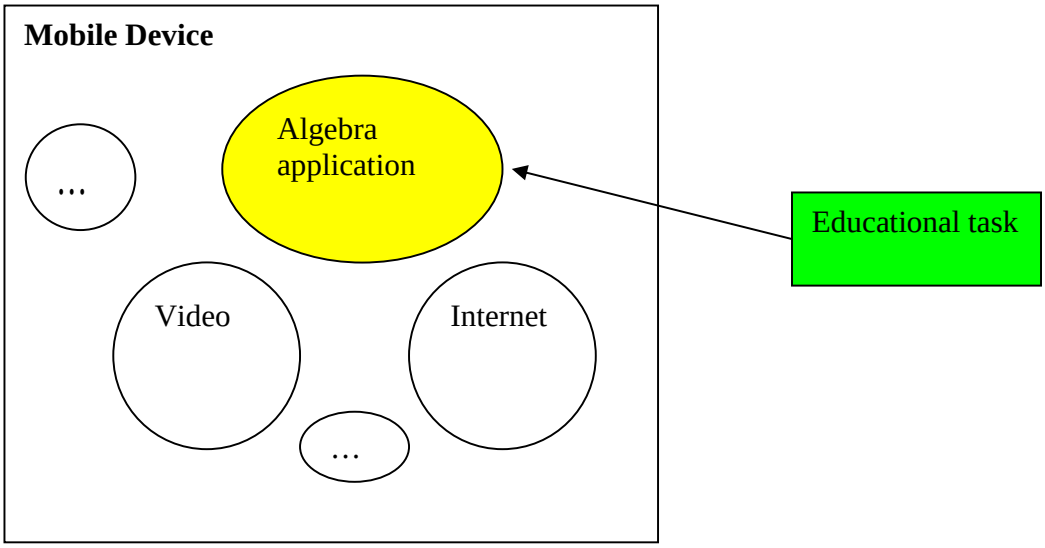
with computers, we should examine how the rapid improvement and development the cellular phones technology offers and the mobility, availability, low price and familiarity their new communication modes provide can contribute successfully to educational advancement.

One of the major goals of future research should be studying the practices involved in uses of mobile services and mobile applications by teachers and students,. thus further encouraging developments of educational applications over the cellular, and enhancing the m- learning concept in general. Questions of user interface designs should be set and explored, model specifications and content design frameworks should be questioned and established and practical conclusions should be set.

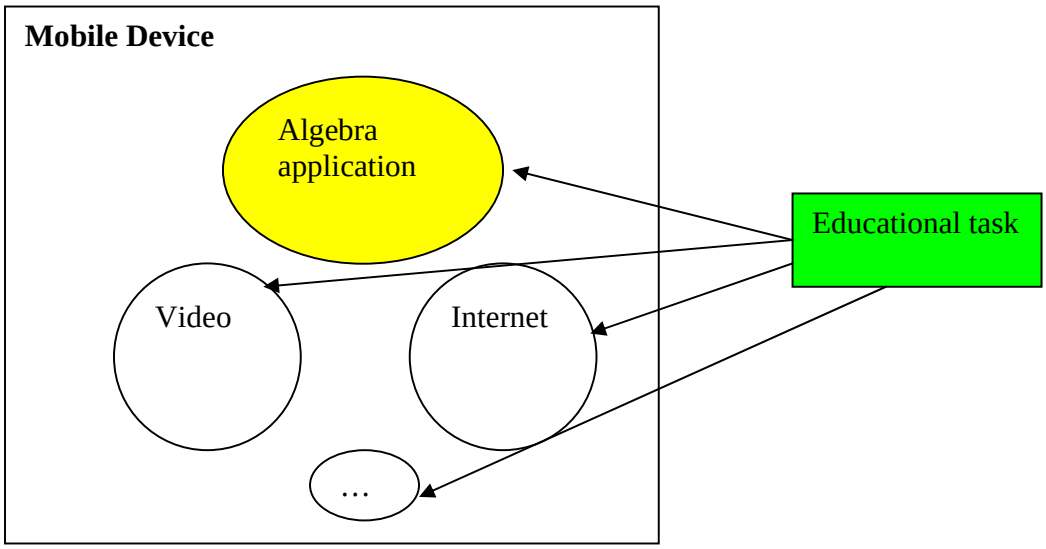
The major goal of research is to learn the implications of the **mobile environment** on the human being's learning. Theoretical basis includes psychological aspects of cognition, perception, human factors principles as well as learning theories. This knowledge will outline the practical design of the educational applications over the cellular phone.

Educational applications over the cellular can be designed and examined in three ways:

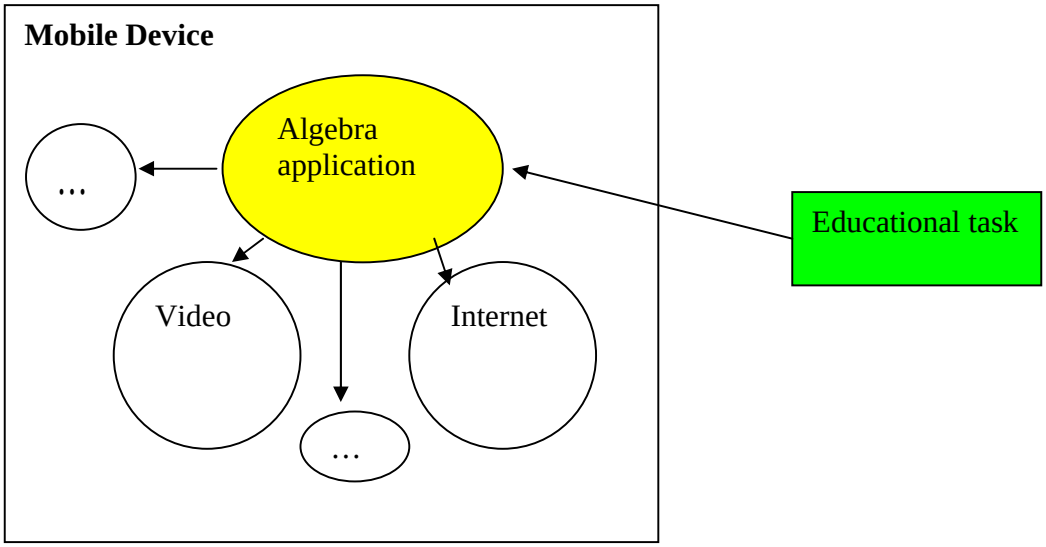
1) *Educational applications as small sets of learning experiences on mobile device*: for example: installing an application in Algebra on the cellular, let the students work with it according to a pre defined curricula, watch their actions, gather and sum all activities data, have free communication channels (talking, questioner etc) regarding their experience and more. Research of this kind is important in order to examine a specific application thoroughly, regarding its use and design.



2) These studies are also the basis for another direction of *research which aims to examine the whole cellular environment as a learning environment.*



The research design will use many of the features of the cellular phone (not set for educational purposes) for creating educational environment. For example: a learning task which directs the student to use the mobile functions (internet, SMS etc) as well The specific educational application installed on it.



3) Other studies could *establish educational applications that use the multi-tasking abilities of the mobile phone as internal modules of the application itself, thus creating a micro world.* An example is an educational application in mathematics which uses the internet for gathering data, uses SMS, MMS, videos, emails to communicate and so on, all are via menus in the application itself.

In order to gather authentic reliable interesting results, the mobile devices used in the research should serve as the student's mobile phone by all means (private phone calls, games and all other non educational activities he uses his phone for). This is important in order to keep all interfering variables out of the game, and to simulate the real environment of students: student have **one** mobile device, thus make it available and convenient in everyday life.

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