

# The Influence of the Characteristics of Mathematical Outdoor Activities in Mobile Environments on Students' Emotions

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**Abstract**—This research attempted to find out how the characteristics of outdoor activities carried out with the mobile phone influence students' emotions. The research findings point at the following components related to the activity as influencing students' emotions: The activity novelty, the activity theme (related to everyday life, related to a new subject related to the students themselves or to an issue or a subject that the students like to do, etc.), the activity conditions (its physical part is easy/uneasy to perform, resources are available, etc.), the outer environment conditions (hot, warm, cold, etc.), the roles which the activity enables (these roles may or may not satisfy a student), the learning method enabled in the activity (exploring mathematical ideas independently, exploring mathematics collaboratively, etc.), the challenge or competition associated with the activity (it needs persistence, attention, etc.). These components show that taking care of students' learning emotions in outdoor mathematical activities can be achieved through paying attention to different aspects of the activity which are outlined above.

**Index Terms**—activity's characteristics, mobile phone, technological environment, students' emotions, affect aspect

## I. INTRODUCTION

Students' learning emotions have become a growing research area in educational psychology [1]. This research attempts to shed light on an important issue in this area: the relationship between the characteristics of mathematical outdoor activities and students' learning emotions while carrying the activities out. Some researchers examined the relation of the learning environment with students' emotions ([2], [3], [1]). The current research is concerned with a similar relation, but in an environment that includes the cellular phone as a technological learning tool and outdoor real life activities as learning activities. This research could be considered complementary to the study of ref [4], but it is concerned primarily with the activity, its characteristics and influence on the different students' emotions, while ref [4] put emphasis on the single emotion and how it is affected by the whole educational scene: the activity, the educational environment, and the student's conditions.

## II. LITERATURE REVIEW

### A. Students' Emotions

Researchers examined students' learning emotions and their influence at students' learning experiences. Ref [5]

describes emotions as a powerful factor which encourages or inhibits effective learning and study approaches. Specifically, ref [5] points at shame and pride as influential emotions in the classroom's learning experiences. This influence is due to shame and pride being fundamental in the formation of confidence, anxiety and fear. Thus, pride and shame are central in the construction of identity, and thus they are significant in theorizing the relation of emotion and learning.

Specifically, researchers examined students' emotions while learning mathematics. For example, ref [6] examined younger students' (Grade 2 and 5) emotions while learning mathematics. The following three emotions were the most common in Grade 2 mathematics classroom: (1) being happy, (2) being focused, and, (3) it feels hard. The responses were sorted into one half that is negative and one half that is positive. In Grade 5, the most common emotions were: (1) Having fun, (2) Being bored, and, (3) the easiness of starting to chit-chat. The responses were sorted into negative and positive feelings, but there was a majority of negative responses.

Some researchers examined students' emotions associated with doing mathematical assignments or during problem solving (ref [7], ref [8]). Ref [7], depending on previous researches, described the importance of emotions during mathematical problem solving, saying that emotion can organize, focus, disrupt, distract or energize problem solving, where the influence of emotion can be immediate or delayed. Further, the authors describe emotions as influencing one's mathematical powers.

Ref [8] describes students' emotions during doing assignments that include collaborative and individual options, class presentations, on-line and computer assisted practice and assessments, as well as unit assignments of modeling, graphing, and writing. Ref [8] found that a surprisingly low response was given to the emotion of pride. At the same time, students indicated satisfaction as their dominant positive emotion. Further, frustration was higher than dread, where only the in class testing was dreaded.

Researchers examined also the relation of students' emotions with other educational constructs, for example with students' test anxiety, students' achievement or students' perceptions of their learning environment ([9], [2], [10], [3], [11], [1]). Ref [3] found that students' perceptions of the teacher as negative and unfriendly were moderately correlated to test anxiety, while students' perceptions of the teacher as positive and friendly showed no significant relationship to individual levels of test anxiety.

Ref [11] found that students' emotions experienced during a mathematical achievement test were related to their achievement. The authors emphasized that students experience different levels of positive and negative emotions according to their level of academic achievement in mathematics. Students with poor achievement outcomes would probably feel anxiety, anger and boredom, while students who do well experience more enjoyment. Regarding the relation of students' emotion's type to the level of their achievement, ref [11] found that students who performed average or well on the test experienced more enjoyment while working on the test than students who did poorly. Furthermore, students who did very well on the test reported the highest level of retrospective enjoyment. In contrast, the emotions of anxiety and anger were located between the middle and bottom performance levels. Regarding the feeling of boredom, it was found that it lied between the bottom and top tests scores, indicating that students may be bored for different reasons.

Ref [10] studied the relation of students' perceptions of their learning environment to their emotions while learning Latin. They found that individually perceived positive reinforcement of achievement, teacher enthusiasm, and elaborative instruction were positively related to feeling of enjoyment and pride, and negatively related to feelings of anger and boredom. On the other hand, achievement pressure from the teacher proved to be positively related to student anxiety and anger, and negatively related to enjoyment and pride in Latin. Another study which examined the affective and cognitive outcomes of the perceptions of classroom environment is that of ref [9] who found positive correlations between students' perceptions of participation, involvement, affiliation, task orientation, order and organization, and rule clarity, and students' enjoyment of science lessons. A third study which examined the relation of students' perception of their learning environment with their experiences of emotions is that of ref [2] who found that the higher the students judged their mathematics teacher's quality of instruction, the more they reported to experience enjoyment, and the less they reported to experience anger and boredom. High individually perceived quality of instruction was also related to slightly reduced individual levels of anxiety in mathematics. Very strong effects were also found for perceived peer esteem, which was positively related to individually reported enjoyment and negatively related to anxiety, anger, and boredom. Moreover, individually perceived punishment behavior on the part of the teacher was not related to the individual experience of enjoyment, but was significantly positively related to the experience of anxiety, anger, and boredom. Finally, individually perceived competition was not only positively related to individually experienced anxiety and anger, but also to enjoyment and boredom.

Some researchers examined how the learning environment which includes students' parents influenced students' emotions. Ref [1], depending on previous researches, pointed that studies do not agree regarding the influence of parents on students' learning emotions. Further, they mentioned that some studies indicate that students enjoy doing homework with parental assistance more than doing it alone, while other studies showed that for many students parental homework involvement is a stressor. Ref [1] explain that the different findings indicate that students' emotions during learning are not primarily influenced by

the mere presence or absence of parental involvement, but rather by its quality. The writers refer also to the influence of the quality of instruction at home and in school on students' learning emotions. For example, autonomy supportive instruction, emotional support, and a clear structuring of learning foster students' emotional well-being. By contrast, over-structured and controlling instruction and negative feedback generally seem to have a negative impact on students' emotions.

### B. *Mathematics Mobile Learning*

Mobile devices in general and cellular phones in particular have been used in the mathematics classroom for more than a decade now. Roschelle and colleagues conducted several experiments using mobile devices in the mathematics classroom. For example, ref [12] examined the use of mobile devices in mathematics and science learning by implementing several activities that became possible owing to the availability of mobile devices, including: (a) distribution: sending the same document to all students, (b) differentiation: sending different parametric definitions to each student in a systematic way, (c) contribution: forwarding a function or mathematical data constructed by one student to a friend or teacher, (d) harvesting: following the collaborative work of several students, constructing a set of functions or data that are related to each other but different; and (e) aggregation: combining functions or data that are in some way related and presenting them usually in public (anonymously or not). The study found that mobile learning promises access to applications that support learning anywhere, anytime, and that this type of learning supports both adults at the workplace and students in classroom learning. Ref [13] found that the use of mobile devices in the mathematics classroom made the class more (a) student centered, (b) assessment centered, (c) knowledge centered, and (d) community centered.

Ref [14] studied the learning processes and experiences of preservice teachers learning mathematics in a cellular phone environment and examined how socio-cultural and situated learning aspects were reflected in these processes and experiences. They found that the contribution of the cellular phone environment "lies not only in making dynamic mathematical applications more available, but also in supporting the execution of tasks that are closer to the students' experiences and more relevant to them, which has the potential to enhance experiential learning." The authors concluded that the participants' learning experiences contributed to their personal learning, which in turn motivated this learning.

Researchers also examined students' perceptions of learning with cellular phones. Ref [15], for example, examined the perceptions of middle school students about the use of cellular phone midlets and web applets in learning mathematics and how they differentiate between the different tools. He reported that the students were aware of the following aspects of the tools: availability, portability, collaboration aspect, communication aspect, the size of interface, and usability. The students used these aspects to describe their experience in using the tools to learn mathematics, to differentiate between them, and to decide which tool they would use in their future learning and how they would use each tool. A higher proportion of students preferred the cellular phone as a learning tool due to its portability and communicability.

Researchers considered also the conditions and consequences of learning mathematics with the cellular phone. Ref [16] found that what affected the students' learning in the cellular phone environment were the characteristics and technologies of the cellular phone, the requirements and topics of the mathematical activities, the learning setting (inside or outside the classroom), the intention of the researchers who participated in the teaching processes, and the involvement of the school principal and the coordinating teacher. The consequences of the mathematics learning in the cellular phone environment were: the students took control of their learning, they connected mathematics with real life phenomena, they developed a new approach to mathematics where they looked at it as an applied science, and they worked as mathematicians.

### III. RESEARCH RATIONALE, GOALS AND QUESTION

#### A. *Research Rationale and Goals*

Though some research has been done on the relation of students' emotions to various components of their learning ([9], [17], [18]), little research has been done on the relation of students' emotions to the characteristics of the activity in technological environments. The need for this research comes also from the fact that the combination of outdoor activities and technological tools may cause mathematics students to feel positive emotions while learning, so the current research could give a direction how to influence positively students' learning of mathematics through influencing positively their learning emotions. This research puts emphasis on the activity characteristics and how the different characteristics influence students' emotions. This is in contrast to ref [4] who studied how every emotion is influenced by the whole educational scene, including the outer environment characteristics and the students' conditions.

#### B. *Research Question*

What is the relation of students' emotions during carrying out outdoor mathematical activities with the cellular phone to the characteristics of the activities?

### IV. METHOD

#### A. *Research Setting and Participants*

The experiment took place in a middle school in Baka in Israel from mid-January to mid-April in the academic year 2008-2009. It was led by three pre-service teachers majoring in mathematics and computers in Al-Qasemi Academic College of Education. The preservice teachers carried out a project that involved teaching mathematics using cellular phones. The project was the preservice teachers' main assignment in a mathematics didactics course which emphasized the role of technology in mathematics education. The pre-service teachers selected thirty Grade 8 students (age range 14-15 years) to participate in the project. The selection was based on the interest of the students and ownership of an appropriate cellular phone (not all the selected students had an appropriate cellular phone, and some of them asked their parents to buy for them a Java-enabled phone). The students had no previous knowledge about the topic of functions. Part of the learning was performed by means of outdoor activities that involved exploring the mathematics of real life phenomena (The relationship between the height of a person

and his/her weight, the relationship between the longest circumference of a rock and its height, etc.). The students took advantage of the various characteristics of cellular phones in their explorations. The other part of learning was performed in the classroom, where the students discussed the graphic and algebraic results that they obtained and reflected on their work outside the classroom.

The students worked in groups of 4-6. They were required to find mathematical relations in real world phenomena and worked on these relations out of class. The students decided themselves which roles they would play (measuring, observing, writing down the observations, assigning points in midlets, taking pictures, etc.), and made decisions about altering these roles when necessary. The decision regarding the roles was made collectively. The students also discussed the results that they obtained, referring to the graphs and algebraic rules that fit the real world phenomena. This discussion was carried out in the classroom.

Initially, the students performed the activities suggested by the pre-service teachers. Later in the experiment, after the students had carried out eight real world activities, they started to develop activities themselves by suggesting real world activities they judged to be executable with cellular phones. The students usually started from a specific suggestion and proceeded to develop it until they considered it to be worth performing.

#### B. *The Mathematics Software*

The middle school students worked with cellular phone software (midlets) that support the learning of algebra and geometry. The midlets developed by Yerushalmy and Weizman (2007) in ref [19] can be downloaded from Math4Mobile site which belongs to the Institute for Alternatives in Education that operates within the Faculty of Education at the University of Haifa. To perform the activities assigned to them, the students used the algebraic midlets and various tools and technologies embedded in their cellular phones. The students used mostly the Fit2Go midlet, which enables users to draw specified points and fit a linear or a quadratic function to them. When a student needs the midlet to fit a linear or a quadratic function to some points, the midlet provides the graph and algebraic rule of the function if such a function exists; if not, it displays the graph and algebraic rule of a function that passes through some of the points drawn.

#### C. *The Activities*

Some of the activities will be described in the findings before describing the students' emotions associated with them.

#### D. *Data Collection Tools*

The pre-service teachers were required by their instructor (the author) to interview the students not only about building mathematical knowledge but about other aspects too. These aspects included students' collaboration, the development of mathematical community and students' emotions during the activities. The later collected data was used in this research.

### E. Data Analysis

*Coding the students' emotions regarding every outdoor activity they carried out:*

The first two stages of the constant comparison method (see ref [20]) was used to analyze the data regarding students' emotions when learning mathematics in the cellular phone environment. These stages were:

**Categorizing data:** putting together data expressions or sentences that imply reasons for a specific students' emotion, for example, putting together all expressions or sentences that imply reasons for students' pleasure when learning mathematics outdoors with the cellular phone.

**Comparing data:** comparing expressions or sentences within each previously built category. This would give rise to sub-categories. Let's take for example the category 'pleasure', comparing expressions or sentences in this category may give rise to the subcategories: pleasure for working outdoors, pleasure for using the cellular phone, pleasure for being equal with teachers.

### F. Relevance of the data analysis to the setting and theme of the study

The objective of the study was to find the relation of students' emotions in outdoor mathematical activities to their characteristics. The use of the constant comparison method to identify categories of students' emotions when learning mathematics outdoors by using the cellular phone and the relation of these emotions to the activities characteristics is supported by use of this method by other researchers who studied emotions, for example, ref [21] used the constant comparison method to analyze data collected by interviewing teachers regarding their students' emotions associated with writing, as well as their own emotions associated with teaching writing.

## V. FINDINGS AND DISCUSSION

To find the relations of the characteristics of an activity to students' emotions while carrying it out, the activity is described first and then the reported students' emotions associated with it. Only the activities that help associate students' emotions with the activities characteristics will be described. All the students' names mentioned are pseudo names.

### A. Out of classroom activity 1: The relationship between the height of a person and his/her weight

*Activity description:*

The members of every group of students measured the height and the weight of every member of the group, wrote down the measurements and then the students who had cellular phones plotted the measurements as points in the midlet Fit2Go. Afterwards the students returned to the classroom where every group shared with the other groups their own measurements and the appropriate function obtained, so a discussion started regarding the correctness of the findings and their meanings.

When interviewing the students about this activity, Dina said: I felt comfortable when carrying out the activity because its procedures were easy. Amina referred to the short time that the activity took as the reason why they felt comfortable during carrying it out. Shadi referred to the availability of everything that was needed for the activity as the reason why they were comfortable carrying

the activity out. Amina said: "I did not feel the passing of time during the activity because the activity was easy and it took short time".

Shaden said that she was enthusiastic to carry the activity because it was an activity about oneself. Baha related the topic of the activity - being about the self as the reason for his increased interest to carry out the activity. Baha explained further, that the activity being about the self made him curious to know its results, and thus he was so interested to carry it.

Students' emotions associated with the first activity, as well as the activity's characteristics which caused them are summarized in Table I.

TABLE I.  
STUDENTS' EMOTIONS IN THE FIRST ACTIVITY

<i>The activity characteristics</i>	<i>Resulting students' emotions</i>
<ul style="list-style-type: none"> <li>• Activity easiness</li> <li>• Performing short time</li> </ul>	<ul style="list-style-type: none"> <li>• Feeling comfortable</li> <li>• Not feeling the passing of time</li> </ul>
<ul style="list-style-type: none"> <li>• Availability of resources</li> </ul>	<ul style="list-style-type: none"> <li>• Feeling comfortable</li> </ul>
<ul style="list-style-type: none"> <li>• Activity involving the students themselves</li> </ul>	<ul style="list-style-type: none"> <li>• Being enthusiastic to carry out the activity</li> <li>• Being curious to know the results of the activity</li> <li>• Having interest in the activity</li> </ul>

Students' emotions during the weight/height activity show that the participating students were enthusiastic about, curious and interested in mathematics which is connected to them. Bell, as reported in ref [22], emphasizes the connection of mathematics to people's life, saying that mathematics, from Babylon and Egypt to the present, is generally appreciated as the primary source of workable approximations to the complexities of daily life. Ref [23] examined how students in years 5 to 8 describe their ideal mathematics lessons, and found that the students value the use of materials and connections from their life. The findings of this research point that in order to encourage students' positive emotions we should give them activities related to their life.

### B. Out of classroom activity 2: The relationship between the time since lighting a candle and its height: lighting a candle and measuring the height after different periods of time

*Activity description:*

The students lit candles in the school yard, but the wind put their light out. Therefore, the students began to discuss where they should carry out the experiment. Some groups decided to do the experiment in one of the classrooms, while other groups gathered around the candle to keep it lit up. The students in one group chose to measure the height of the candle every minute, but found that the height of the candle does not change much during this time. Therefore, they decided to increase the time period in which they measure the height of the candle again. Before each step in the experiment the students discussed how they should perform it and what the possible outcomes of this step might be. Some groups worked faster than other groups due to proper coordination among them.

The girls in one group put out the candle each time they wanted to measure its height. When asked why they did so, they justified their doing by the need not to lose any part of the candle during the measurement. The boys in one group measured the height of the candle without putting it out. When asked why they did so, they justified their doing by the need not to lose heat; so the results of the experiment will not be affected. During the measurement process, one of the students in each group registered the results on a sheet of paper. The measurement was carried out by different students in a group, where every time a different student performed it. When the students completed the measurement and the registration of the results, one or more of the members of the group began to assign points in the coordinate system of the midlet Fit2Go and tried to fit a linear or quadratic function to the assigned points. Further, during the experiment, one student in the group was responsible of taking pictures, while another student was recording important moments to document the experiment. When interviewing the students about this activity some of them said that it was not comfortable to carry it out because the candle light kept going out due to the wind. The girls in the group which kept putting out the candle during the measurement process said that it was a bit uncomfortable to keep lighting and putting out the candle. The boys in the group who measured the height of the candle without putting it out said it was uncomfortable for them to measure the height of the candle while it was still burning.

Khalid said: "I enjoyed doing more than one action in the activity: lighting the candle, measuring its height, measuring the time that passed since lighting it, finding the mathematical relation in the midlet".

Halim used the expression 'content' in place of 'enjoyment', saying: "I was content doing different actions during the activity".

Nidin said: "I enjoyed the activity, and I did not feel the passing of time as a result of this enjoyment".

Students' emotions associated with the second activity, as well as the activity's characteristics which caused them are summarized in Table II.

TABLE II.  
STUDENTS' EMOTIONS IN THE SECOND ACTIVITY

<i>The activity characteristics</i>	<i>Resulting students' emotions</i>
<ul style="list-style-type: none"> <li>• Activity outer conditions</li> <li>• Activity conditions</li> </ul>	<ul style="list-style-type: none"> <li>• Not feeling comfortable</li> </ul>
<ul style="list-style-type: none"> <li>• Performing more than one action in the activity (the activity enables multiple learning actions)</li> </ul>	<ul style="list-style-type: none"> <li>• Enjoying the activity</li> <li>• Not feeling the passing of time</li> <li>• Being content</li> </ul>
<ul style="list-style-type: none"> <li>• Activity outer conditions</li> <li>• Activity conditions</li> </ul>	<ul style="list-style-type: none"> <li>• Not feeling comfortable</li> </ul>

Students' emotions in the candle activity were influenced from the activity conditions, as well as its context conditions. In addition they were influenced from the ability of the students to perform various actions during the activity. The availability of various actions which the student can perform fills the participant's time, so he/she does not feel the passing of time. In addition, it is expected that the doing of various actions will make the participant content regarding his/her learning in the

activity for he/she participates actively all along the activity and at the same time has different learning experiences. This explanation agrees with ref [24] who points at the behavioral activity of the student as influencing his/her emotions and motivation to learn. Further, He/she would probably enjoy doing one or more of the performed actions or enjoy the rich variety of actions.

### C. *Out of classroom activity 3: The relationship between the longest circumference of a rock and its height*

#### *Activity description:*

The students argued which rock to measure: small rock, large rock or a medium one, or whether they should include rocks of various sizes. When the students began measuring the circumference of a large rock, they discovered that one student was not capable of carrying out the measurement alone, so at least two students were needed to perform the measurement.

When interviewing the students about this activity, Husam said: "I enjoyed carrying it out because I never thought that mathematics had anything to do with rocks". Others used the expression 'curiosity' or 'enthusiasm' in place of 'enjoyment' saying that they were curious (or enthusiastic) to carry the rocks activity because they never thought that mathematics can be applied to rocks.

Salim said: "I enjoyed the rocks activity because I was exploring math ideas independently". Rula said: "I was satisfied to measure the circumferences of rocks, and this made me enjoy it". On the other hand, Hanan said she did not enjoy the rock activity because she wanted to participate in measuring the circumference of a rock, but her group did not let her do that. Asma referred to not participating in the measuring as the reason why she did not feel comfortable during the activity.

Some students said that performing the activity in the wild away from the school made them enjoy the activity. Others said that they enjoyed measuring the rocks' circumference because they worked collaboratively to do that.

Asil said that it was not comfortable to carry out the rock activity because it was difficult to measure its circumference.

Amal said: "the activity made me enthusiastic because I did mathematics where I never thought to do mathematics". On the other hand, Kamal said he was not enthusiastic to carry out the rocks activity because of some conditions associated with it or with its context, for example because (1) they got tired measuring rocks' circumference, (2) it was so hot out. Some students were not enthusiastic for they were dissatisfied with their assigned role.

One student said that she was interested to carry out the rock activity because it involved real life. On the other hand, one student said that she was not interested to carry out the rock activity because she thought it was too difficult for her to measure the circumference of big rocks.

Students' emotions associated with the third activity, as well as the activity's characteristics which caused them are summarized in Table 3.

TABLE III.  
STUDENTS' EMOTIONS IN THE THIRD ACTIVITY

<i>The activity characteristics</i>	<i>Resulting students' emotions</i>
<ul style="list-style-type: none"> <li>• Doing mathematics in a novel way</li> </ul>	<ul style="list-style-type: none"> <li>• Enjoying the activity</li> <li>• Being curious</li> <li>• Being enthusiastic</li> </ul>
<ul style="list-style-type: none"> <li>• Having the option to do mathematical independently</li> <li>• Having the freedom to carry out the chosen role</li> <li>• Performing the activity in the wild</li> <li>• Working collaboratively</li> </ul>	<ul style="list-style-type: none"> <li>• Enjoying the activity</li> </ul>
<ul style="list-style-type: none"> <li>• Not Having the freedom to carry out the chosen role</li> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>• Not enjoying the activity</li> <li>• Not feeling comfortable in the activity</li> </ul>
<ul style="list-style-type: none"> <li>• The conditions of the outer environment</li> <li>• The conditions of the activity</li> <li>• Not having the freedom to carry out the chosen role</li> </ul>	<ul style="list-style-type: none"> <li>• Being not enthusiastic</li> </ul>
<ul style="list-style-type: none"> <li>• The activity's conditions</li> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>• Being not comfortable</li> <li>• Being not interested to carry out the activity</li> </ul>
<ul style="list-style-type: none"> <li>• Doing mathematics that involved real life</li> </ul>	<ul style="list-style-type: none"> <li>• Being interested to carry out the activity</li> </ul>

Students' emotions in the rocks activity also emphasize the influence of the activity conditions, as well as the activity context, on the participating students' emotions. This influence of the learning context on students activity is mentioned in the literature, for example ref [25] argues that knowledge is situated, being in part a product of the activity, context, and culture in which it is developed and used. This research results indicate that not only knowledge is situated and context related but also students' emotions while carrying out mathematical activities. This also agrees with ref [24] who describes the learning environment as influencing the cognitive/metacognitive activity of students, as well as their emotions and motivation to learn.

Another important aspect which influenced students' emotions in the rocks activity is students' satisfaction of their role and participation, which could be associated with the activity conditions and options. Ref [9] found positive correlations between students' perceptions of their participation and involvement, and their enjoyment of science lessons. This is what happened in this research too; students' satisfaction/dissatisfaction of their role influenced their enjoyment of the activity.

#### D. Out of classroom activity 4: Throwing a ball

##### Activity description:

In this activity, the students were composed of four groups. Each group carried out an experiment which involved throwing a ball in a different situation and measuring the time and distance that the ball travelled. The situations included: throwing the ball on a flat straight surface, throwing the ball uphill, throwing the ball downhill and throwing the ball upward in the air. In each of the first three situations, four students stood in a straight line, 10 meters apart from each other. They measured time in tenths of seconds using the stopwatch in their cellular phones. Some students used their cellular phones to take pictures of the experiment and record

videos. Other students registered the results of the experiment in tables on worksheets prepared by the teacher. Some students assigned points, according to the registered results, in the coordinate system of the midlet Fit2Go and fitted a suitable function for the points.

When throwing a ball upward, two students stood on each floor of the first two floors of the school building. The heights of the windows in these floors were measured before starting the experiment. The students measured the time it took the ball to reach each floor using their cellular phones. The measurements were done as the ball was moving upward, and as it moved downward. One student stood in the schoolyard and measured the total time since throwing the ball until it returned to the ground. All the measurements were registered in an appropriate table, where the height 'zero' (the ground's height) was registered in two situations: when throwing the ball and when the ball reached the ground downward. In the classroom discussion regarding the experiments, the students presented the results of the measurement, the mathematical models they acquired and the characteristics of these models. The students referred to the rate of change of the function, which was almost constant when throwing the ball on a flat surface, decreasing when throwing it uphill and increasing when throwing it downhill. They analyzed the resemblance between the shape of the graph (parabola) of the function that described the relationship between the height of the ball and the time, when throwing the ball upward in the air, and the movement of the ball itself that they saw in their own eyes.

When interviewing the students about this activity some of them said that they enjoyed carrying out the ball activity because it involved everyday life. Others said that they enjoyed it because it involved playing or something that they like to do.

Some students said that they enjoyed the ball experiment because it was new for them to work with mathematics while playing. Other students said that they were comfortable during the activity because everything was done in a team. Some students said that they were pleased when they finished the activity and got results similar to those that they guessed at the beginning.

Some students said that they were enthusiastic to perform the activity because: (1) it was like playing for them; (2) they used their own phones to take pictures, measure the time and find the function that fits the distance that a ball travelled to its time; (3) they wanted to verify if their guess about the resulting function was right (regarding throwing the ball uphill); and (4) it was new to them to find the mathematics of throwing a ball.

One student said he felt time was not passing because it was hot out and he needed to take pictures during the whole activity.

Students' emotions associated with the fourth activity, as well as the activity's characteristics which caused them are summarized in Table IV.

Students' emotions in the ball activity show different components of students' learning that influence positively their learning emotions: doing mathematics in a novel way, using tools to learn mathematics, doing mathematics collaboratively, doing mathematics that is involved with real life or with playing, or that is related to something

that we like to do ordinarily. These findings are accumulated to other research findings which point at tools, playing and connections to real life as influencing positively students' learning of mathematics, for example ref [26] says that rote computations and tedious algebraic manipulations have turned students from mathematics for a long time, thus having calculators which do the computations and tedious manipulations change the attitude of students towards mathematics. Ref [27] says that the usage of manipulatives with concrete experiences increases, on one hand, students' conceptual understanding and their problem solving skills, and on the other hand promotes their positive attitudes towards mathematics. In our case, the usage of the cellular phone with real life activities influenced mostly positively, but sometimes negatively, students' learning emotions.

*E. Out of classroom activity 5: the relation between the time that has passed since starting to fill a container and the size of water in it*

*Activity description:*

The students worked with different container shapes, one at a time. They found difficulty determining the size of water in the different containers. To overcome this difficulty they used different strategies, for example estimating the size in terms of small plastic cups or mugs. Some groups performed the actual measuring.

When interviewing the students about this activity the students in one group said that they were pleased when their group finished the activity because it was a difficult one. The students of another group said that they were pleased when they finished the activity because they finished it before the other groups.

One student said that the activity needed much attention, so she got enthusiastic to finish it to see what it entails.

One of the students said she felt that the container's activity took a lot of time, and she referred to the difficulty of measuring the volume of water as the reason for that feeling.

Students' emotions associated with the fifth activity, as well as the activity's characteristics which caused them are summarized in Table V.

Here too the conditions of the activity influenced students' learning emotions. Further, these emotions were influenced by the challenge felt by the participating students regarding carrying it out because of its relative difficulty. Ref [28] point that challenge gives students the intrinsic rewards that come from setting goals and working strategically to attain them, and that it is at the juncture of their cognitive, conative and affective growth. Ref [2] found that individually perceived competition was not only positively related to individually experienced anxiety and anger, but also to enjoyment and boredom. This research indicates that challenge can make students pleased and proud of their performance, not only individually but as a group too.

*F. Out of classroom activity 6: The relation between the temperature of the water in a container and the time required for a cube of ice to melt in that water.*

This activity was suggested by the students themselves. They used a thermometer to measure the temperature of

the water in the container and their cellular phone to measure the time it took the cube of ice to melt. The students had a dispute how to tell if the entire cube had melted and if to believe their eyes or to bring a magnifying glass to make sure that the entire cube had indeed melted.

When interviewing the students about this activity, some said it was so interested to work on the ice melting activity because it was their collective suggestion. On the other hand one students said he was not interested to carry out the ice activity because he was required to take pictures of the activity; something that he had done before.

Students' emotions associated with the sixth activity, as well as the activity's characteristics which caused them are summarized in Table VI.

Students are always interested in carrying out activities that they suggest, for they suggest activities that are related to their own world and that they think they can

TABLE IV.  
STUDENTS' EMOTIONS IN THE FOURTH ACTIVITY

<i>The activity characteristics</i>	<i>Resulting students' emotions</i>
<ul style="list-style-type: none"> <li>• Doing mathematics involved with real life</li> <li>• Doing mathematics involved with playing</li> <li>• Doing mathematics involved with something that one likes to do</li> <li>• Doing mathematics in a novel way</li> </ul>	<ul style="list-style-type: none"> <li>• Enjoying the activity</li> </ul>
<ul style="list-style-type: none"> <li>• Doing mathematics collaboratively</li> <li>• Planning the activity from the beginning</li> </ul>	<ul style="list-style-type: none"> <li>• Being comfortable during the activity</li> </ul>
<ul style="list-style-type: none"> <li>• Getting mathematical results as guessed</li> </ul>	<ul style="list-style-type: none"> <li>• Being pleased</li> </ul>
<ul style="list-style-type: none"> <li>• Doing mathematics playfully</li> <li>• Using the personal phone to do various actions in the activity</li> <li>• Doing mathematics in a novel way</li> <li>• Having the intention to verify their guess regarding the outcome of an activity</li> </ul>	<ul style="list-style-type: none"> <li>• Being enthusiastic</li> </ul>
<ul style="list-style-type: none"> <li>• The conditions of the outer environment</li> </ul>	<ul style="list-style-type: none"> <li>• Feeling the passing of time</li> </ul>

TABLE V.  
STUDENTS' EMOTIONS IN THE FIFTH ACTIVITY

<i>The activity characteristics</i>	<i>Resulting students' emotions</i>
<ul style="list-style-type: none"> <li>• Finishing a difficult activity</li> <li>• Finishing first an activity</li> </ul>	<ul style="list-style-type: none"> <li>• Being pleased</li> <li>• Being proud</li> </ul>
<ul style="list-style-type: none"> <li>• Needing attention</li> </ul>	<ul style="list-style-type: none"> <li>• Being enthusiastic</li> </ul>
<ul style="list-style-type: none"> <li>• The conditions of the activity</li> </ul>	<ul style="list-style-type: none"> <li>• Feeling the passing of time</li> </ul>

TABLE VI.  
STUDENTS' EMOTIONS IN THE SIXTH ACTIVITY

<i>The activity characteristics</i>	<i>Resulting students' emotions</i>
<ul style="list-style-type: none"> <li>• Being students' own suggestion</li> </ul>	<ul style="list-style-type: none"> <li>• Being interested</li> </ul>
<ul style="list-style-type: none"> <li>• Not satisfied with the assigned role (the activity performance does not allow carrying out the chosen role)</li> </ul>	<ul style="list-style-type: none"> <li>• Being not interested</li> </ul>

handle. Problem posing, As ref [29] argues, has long been viewed as a characteristic of creative activity in many fields of human venture, and it is common for mathematicians (according to Poincare, as reported by ref [29]) to formulate their own problems, based on their personal experience and interests. Thus mathematics teachers should encourage their students to suggest their own activities and problems. In this way they will become more interested and active in their learning of mathematics.

## VI. CONCLUSIONS

The current research points at the following components related to the activity as influencing students' emotions in outdoor activities in which they use the cellular phone: The activity novelty, the activity theme (related to everyday life, related to issue or a subject that the students liked as playing, related to the students themselves, related to a new subject, etc.), the activity conditions (its physical part is easy/uneasy to perform, resources are available, etc.), the outer environment conditions (hot, warm, cold, etc.), the student roles which the activity enables (these roles may or may not satisfy a student), the learning method enabled in the activity (exploring mathematical ideas independently, exploring mathematics collaboratively, etc.), the challenge or competition associated with the activity (it needs persistence, attention, etc. These components show that taking care of students' leaning emotions in outdoor mathematical activities can be achieved through paying attention to different aspects of the activity which are outlined above.

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