Gaming as Actions

Students Playing a Mobile Educational Computer Game

Elisabet M. Nilsson & Gunilla Svingby, Malmö University

The article presents an empirical study performed in the light of socio-cultural theories, emphasizing the usage of tools as a part of human learning. The aim was to explore what actions emerged in the interaction with, and were mediated by, the mobile educational computer game Agent O*, when collaboratively played outdoors by 17 science students aged 15–16. Video recording was used to gather data. The outcome is a visual and written description of eight more prominent actions and sub-actions that occurred while gaming, including not only actions in direct connection to the actual gaming session, but also actions that emerged in the situation as a whole: the social practice within which the gaming took place. The gaming students came to act as a sort of student-gamer-performer hybrids, alternating between different roles. These and the other gaming actions seemed to have worked as a source of motivation for the students.*

Keywords: action, augmented reality, computer games, handhelds, learning, socio-cultural theory

This article reports experiences gained from an empirical study involving 17 science students aged 15–16 playing the mobile educational computer game *Agent O*. The aim of the study was to explore the actions that emerge in the interaction with, and are mediated by, the computer game, when collaboratively played in a formal school setting. The outcome is a

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description and qualitative analysis of the gaming session, as well as a model for how such actions may be analysed.

The study is grounded in socio-cultural theories, claiming that all learning activities are embedded in a social, cultural and material world, and that human actions and learning are inherently interconnected with the tools available (Gee 2003; Lave & Wenger 1991; Säljö 2005; Vygotskij & Cole 1978; Wertsch 1991). Human action "employs 'mediational means' such as tools and languages, and these mediational means shape the action in essential ways" (Wertsch 1991, 12). Tools are regarded as active rather than passive objects, as they influence how we think, act, and behave. They enable us to do, experience, and learn things that we cannot achieve without the tool.

Technological innovations offer new tools as contexts for learning and action. The question of how technology changes our world is not only related to material advances and technological innovation. There is also a sense in which technology changes the way humans perceive and act upon the world. The last decades' technological development and the emergence of tools such as computers, digital networks, and computer games, have resulted in a new media and communication landscape. These tools have become central carriers and providers of information, knowledge, and values. Many children spend the same amount of time playing computer games, watching TV, listening to music, and surfing on the Internet, as they spend at school (Becker 2008; Säljö 2005). In Sweden, almost 60 % of the boys and one fourth of the girls aged 12–16 use the computer for gaming every day or three to four times a week (Swedish Media Council 2006). About as many use the Internet every day for instant messaging, gaming, school work, and other activities. These experiences have changed the learning and teaching situation of schools. The new generation of learners who are used to adapted levels of difficulty, positive feedback, stimulating demands, and other positive features of complex computer games, will be a challenge to traditional school teaching (Gee 2003, 2004; Shaffer 2007, 2008). Learning in the context of computer games is "not just a matter of what goes on inside people's heads but is fully embedded in (situated within) a material, social and cultural world" (Gee 2003, 8). If education wants to reach out

to them, it has to take children's and teenagers' worlds outside school into account (Gee 2003; Shaffer 2007, 2008).

Research Question

The intention of the study has been to carry out a qualitative analysis and present a description of a gaming session involving 17 students aged 15–16 playing *Agent O* in science education. In line with the theoretical assumptions, the analysis focuses on how students' skills and ways of thinking depend on, and interplay with, the mediating tools that are available when playing. Assuming that human actions and learning are inherently interconnected with the tools utilised and that new actions emerge when new tools are introduced: what kind of actions emerge, and in which ways does learning take place when people play computer games? What kind of tool-mediated-actions emerge when the mediational mean is a computer game, and how could the ensuing learning processes be understood?

The question elaborated on is: what actions emerge in the interaction with, and are mediated by, the mobile educational computer game *Agent O*, when inserted in a formal school setting and collaboratively played there?

The analytic focus is on the gamers' concrete actions during the gaming session. The actions observed are those that are directly connected to the actual game, but also those that emerge in the situation as a whole, between the involved participants and the social practice within which the gaming takes place.

Previous Research on Computer Games and Learning

During the last ten years intensive research activities have been conducted on games and learning in order to explore the learning potentials of computer games (cf. literature overviews by Bergman & Svingby 2005; De Aguilera & Méndiz 2003; De Freitas 2007; Egenfeldt-Nielsen 2006, 2007; Kirriemuir & McFarlan 2004; Linderoth, Lantz-Andersson & Lindström 2002; Mitchell & Savill-Smith 2004; Susi, Johannesson & Backlund 2007). The overall conclusion seems to be that even if several studies show effects on learning as well as on attitudes, empirical evidence is still lacking in support of the assumption that computer games

are advantageous for use in educational settings. Most of the research results presented so far is based on theoretical assumptions, and an understanding of how computer games could be used in practice is lacking. If the links between games and educational objectives are to be considered, more empirically based studies are needed.

Studies exploring the links between learning and computer games can be divided into two main sections (Linderoth 2004, 28). The first consists of studies exploring what the gamers are expected to learn while gaming. This "what" can be divided into two learning objectives: 1a) the gamers' achievement of general abilities and skills (often on a cognitive level), and 1b) what gamers learn from the game theme (the story and content). A number of studies of the first kind (see the overview by De Aguilera & Méndiz 2003) claim that computer games can be instrumental in acquiring abilities and skills like:

> *spatial perception and recognition, development of visual discernment and separation of visual attention, development of inductive logic, cognitive development in scientific/technical aspects, development of complex skills, spatial representation, inductive discovery; iconic code construction, gender construction* (ibid., 10).

Studies in category 1b explore what gamers learn from the game in terms of specific knowledge and values. Such studies are comparatively rare, but some studies report knowledge gains and attitude changes (Bergman & Svingby 2006; Shaffer 2007; Svingby 2005; Svingby & Jönsson 2007).

The second section of computer games and learning research outlined by Linderoth (2004, 28) consists of studies focusing on possible pedagogical strengths and potentials of computer games as providers of learning environments. Linderoth identifies four central arguments brought forward by previous scholars in favour of why computer games and gaming hold pedagogical potentials. Firstly, to play is seen as a natural way to learn and develop. This is a statement with a long history from the research on human development with relation to games and simulations, and has been studied long before the computer games entered the scene (c.f. Huizinga 1955; Sutton-Smith 1971). Secondly, the new generation

of learners has grown up in a different media and communication landscape than did previous generations, and is used to handle and assimilate information in a way for which contemporary educational systems are not built (cf. Fromme 2001; Gee 2003, 2004; Shaffer 2008). The assumption is that computer games could afford learning environments that meet the needs of today's students (cf. Gee 2003; Shaffer 2007, 2008). Thirdly, playing computer games is entertaining, and having fun is a motivational factor that facilitates learning (cf. Malone 1981). Nevertheless the claim that there is a natural link between having fun while playing computer games on the one hand, and better learning the content on the other, is a debatable assumption since empirical studies show that this connection can not be easily made (cf. Ko 2002). Fourthly, computer games provide dynamic representations, and gamers gain experiences of the representation when gaming. The assumption is that such dynamic representations, consisting of combinations of graphics, movement, sound, and text, provide a more authentic representation of what is being represented, something that is thought to be beneficial in learning (cf. Gee 2003; Shaffer 2007). However, some empirical research also claims that the link between the representation and what it represents does not come naturally, and that children playing games do not necessarily treat games as representations of something else (Linderoth 2004). Consequently, if computer games are to be used in educational settings, the gaming actions need to be contextualised in a way that enables the children to make sense of the educationally relevant content.

Advances in mobile technology open up for new kinds of gaming experiences. Computer gaming is no longer only about sitting indoors in front of a stationary computer. It can also be about moving around in an outdoor environment, interacting with the physical world and computer generated digital information simultaneously, for example by using handheld computers connected to GPS (Global Positioning Systems). Researchers interested in computer games and learning recently started to experiment with augmented reality games for the learning of professional competences and attitudes. It is assumed that by bringing the physical world into the game space, mobile gaming has unique educational affordances when compared to purely digital simulations, and provides opportunities for students to develop critical skills, including collabora-

tion, managing uncertainty, and analysing complex systems (Klopfer, Squire & Jenkins 2002; Rosenbaum, Klopfer & Perry 2007; Squire & Klopfer 2007).There are still relatively few studies with a socio-cultural perspective that have been undertaken on mobile gaming actions. The studies brought forward here present findings relating to the analysis and outcome of this article.

Mobile Computer Games and Learning

Klopfer *et al.* (2005) describe two generations of augmented mobile games developed to support science learning. The games present authentic role-playing of augmented reality and participatory simulations. In the first game, *Environmental Detectives* (ED) (Klopfer, Squire & Jenkins 2002), students role-played as environmental scientists in a real world scenario that blended the local physical environment and the game narrative. Working in teams, the players attempted to identify a contaminant and devise plans for remediation. Klopfer, Squire and Jenkins (ibid.) report that the experiences from ED showed that collaboration within groups was strong, while collaboration between groups was limited. In order to promote inter-group collaboration, two new games were created: *Charles River City* (CRC) and *Mad City Murder* (MCM) (Klopfer *et al.* 2005). In these games, the teams received distinct roles, in order to promote collaborative learning between groups. Students were encouraged to sollicit information from other teams, information they could not get themselves. The educational goal was to help students develop investigation and inquiry skills through virtual investigation.

In MCM, as an example, students played the roles of medical doctors, environmental specialists, or government officials, who were trying to solve the mystery by interviewing virtual characters in the game, gathering data samples, and examining governmental documents. Squire and Jan (2007) studied 28 students playing MCM. They explored if the game engaged elementary, middle, and high school students in "scientific thinking, how game structures affect students' thinking, the impact of role playing on learning, and the role of physical environments in shaping learning" (ibid., 1). The outcome of the study suggests that the game offers a model for developing students' scientific literacy, particularly their argumentation skills. The researchers argue that playing the game

immersed students in "a kind of scientific argumentation that is purportedly difficult to achieve and yet desired by science educators as a primary goal of science education" (ibid., 26).

In another study, Rosenbaum, Klopfer and Perry (2007) studied *Outbreak @ The Institute*, a game that simulates a disease outbreak on a university campus. The game was played on handheld computers outdoors by 21 students from a public high school. The handhelds were connected to GPS that provided positioning information and game content, depending on where they were located on the playground. The students took on the roles of doctors, medical technicians, or public health experts, and their mission was to identify the source and prevent the spread of the disease. In order to stop the outbreak, the students had to work in teams and use tools such as diagnostic tests, vaccines and quarantining. There is no actual "end" in the game and no criteria for winning. Instead, the students have to decide themselves what the goals are throughout the game. The purpose was to investigate if the "students perceive the game as an authentic experience" (ibid., 34). An authentic experience is referred to as a sense of taking on "real" problems, and the "question of authenticity hinges on the context in which the task can be perceived as authentic" (ibid., 31). The findings suggest that the students did perceive the game as an authentic experience, feeling personally embodied in the game, shown by their verbal and physical reactions to the virtual disease in the game. Students also experienced their roles in the game in authentic ways, which was demonstrated during game play and in interviews, when the students treated their roles with a serious and responsible attitude.

Facer *et al.* (2004) report a study of 10 students aged 11–12 playing the mobile strategy game *Savannah*. The students played as lions on the savannah, while physically moving in a limited outdoor environment. The challenge for the students was to understand how to survive in this virtual territory. The game was played on handheld computers connected to GPS, and the children used virtual equipment packed in a rucksack, allowing them to get immediate computer feedback. There was also an indoor space called the "Den", where the students could go and access other resources. The study investigated

> *whether the combination of these different features of mobile and games technologies could encourage the development of children's conceptual understanding of, in this case, animal behaviour and interaction with the environment.* (ibid., 400)

The researchers report that the students strongly identified themselves as lions. They acted as if they were experiencing the simulation for real, and they reported that they felt like they had experienced what it was like being a lion on a savannah, and that the game had increased their understanding. The students were jumping in between multiple roles, as they were

> *required to act as 'lions acting as lions', as 'children acting as lions' and as 'children reflecting on their actions and the rules of the game' in order to play better.* (ibid., 405)

Facer *et al.* mean that these characteristics of mobile gaming result in an engaging and more direct experience, in comparison to playing computer games on a stationary computer indoors.

The studies reported above indicate that augmented mobile gaming can be an engaging learning activity, but no empirical conclusions can yet be drawn on the effects of mobile games on learning even though the theoretic arguments are strong. The studies so far report the following:

1. The gamers felt personally embodied when playing the mobile games
2. The gamers identified themselves with the characters they were playing
3. The gamers were taking on and playing with multiple identities (both as students and gamers on different levels of engagement), and reflected upon the relationship between them
4. Students showed enthusiasm for the school tasks when gaming (reported by the teachers participating in the studies)
5. If gaming is to support learning activities in educational settings, the connection between the gaming experience and the learning process must be facilitated.

The Empirical Study

The Game

The tool used in this study was the mobile educational game *Agent O*, which is an outdoor, site-specific game played on handheld computers connected to GPS. The game is inspired by the first and second generation augmented mobile games developed by the MIT Teacher Education Program (Klopfer *et al.* 2005). *Agent O* is designed to be used in science and technology education, specifically dealing with sustainable development and consequences of globalisation (Alexandersson *et al.* 2005; Fergusson, Karlsson & Zhuta 2006). The game aims at presenting students with a challenge that requires basic scientific reasoning, gathering, and valuing of data, as well as discussing alternative solutions. As in MCM, students play in teams assigned with one of three roles, and no team can solve the mystery without collaborating with other groups.

Through GPS the student groups orient themselves in their physical surroundings, while information and clues are obtained via the handhelds. The game builds on a simple, linear narrative structure, with 11 assignments that have to be accomplished in order to solve the case. The assignments are presented as text, still images, or video. It could for example be clues delivered by a non-playing-character (NPC), an item that has to be picked up, or a building that has to be entered. At some points, information must be exchanged between groups in order to proceed in the game. The graphical interface provided by the handheld computer (see Figure 1), presenting a map of the physical playground illustrated by an air photograph of the actual area as well as virtual elements only existing in the game, indicates where to look for clues and additional information.

Figure 1. The interface with a map of the area indicating where the students should look for information. NPCs in the game provide facts and leads.

The story starts with a film screened in the classroom, introducing the agent Karl Stark calling out for help to solve a mystery. A number of people and dogs in the neighbourhood have turned ill, and no one understands what caused this illness. Agent Stark turns to experts (the gaming students) to ask for help in solving the case. After finishing the game, the students have discovered that both humans and dogs are poisoned by the toxic acid phenoxy. However, they do not get to know *how* this substance ended up in the humans and in the dogs. With this question in mind they return to the classroom, where the student groups produce various explanations and are presented with new information. After a discussion lead by the teacher, a closing film is screened, and the whole story is revealed and related to global environmental interdependence.

The Situation, the Sample, and the Procedure

Agent O was played at one occasion during a science education class. 17 students aged 15–16 (9 girls, 8 boys) divided into six groups of 2–4 participated in the study. Additionally, 11 students (9 girls, 2 boys), also divided into six groups of 1–2, documented (through video filming) the gaming student groups. The teacher had informed the students beforehand that they were going to play a computer game, and that a research

group from the university was going to visit them. Apart from the students, other people involved in the session were the ordinary teacher, a student teacher, and the research team, consisting of three university students in interaction design (the game developers), a senior teacher educator, and a doctoral student. The game was played for 90 minutes (during a 2 x 45-minute lesson), and approximately half of the time was spent on the actual process of playing the game outdoors. The rest of the time was spent indoors in the classroom on the introduction, film screenings, and discussions, before and after the gaming session.

After being introduced to the game story by the film, students were divided into groups of two to four students, allotted one of the three roles in the game (journalist, medical or veterinary student), and introduced to the handheld computers. After the introduction, the groups went outdoors to search for clues and information, presented to them via the interface of the handheld computer (see Figure 1). When they had finished the game, they returned to the classroom for further discussions and screening of the closing film. It should be noted that due to technical problems, there were groups that were not able to finish the whole game without help. In order to solve the case, they had to request assistance from the research team.

Gathering Empirical Data

Video recording was employed to gather data, as "[a]udio and video recordings provide researchers with a medium through which they can repeatedly inspect social actions in the context of their occurrence" (Heath & Luff 1992, 10). The outdoor gaming session was filmed by groups of students from the same class as the gaming students. The film makers were briefly instructed to be passive observers, and act as "flies on the wall", to observe their classmates during the gaming session, and try to interfere as little as possible. After the gaming session, they were asked to interview the gaming students about their experiences. As all film groups interpreted the instructions differently, the resulting video films exhibited considerable variation, both when it comes to the content (interviews, angles, length of film sequences, interference, etc), and the film quality (sound, pictures, etc). The students also left out certain parts of the gaming process they did not consider to be particularly interesting,

such as walking between the different points in the game. The intention of the research team during the outdoor gaming session was to be perceived as passive participators, in this context referred to as "present at the scene of action but does not participate or interact with other people to any great extent" (Spradley 1980, 59). Since the technology caused some difficulties, the students came to the research team for help, and the passive participators thereby started to actively participate in the session, which influenced the data gathered.

The Gathered Empirical Data

The gathered and transcribed video data consist of six video recordings (171 minutes). The chosen method for gathering data resulted in empirical data that do not reveal how the different activities during the gaming session were distributed time-wise, since the filming students tended to stop filming when they thought there was nothing of interest to document. Data presenting figures on the proportion of time students spend on different actions can therefore not be obtained. A few film groups filmed the whole gaming session with just a few interruptions, while other groups stopped recording on and off during the whole session. The main part of the empirical data analysed is from actions occurring when students were standing still, which was approximately half of the gaming time. Data from the other part of the gaming time, when the students were moving, were insufficient and poorly documented.

Method of Analysis

The analysis performed is of a qualitative and descriptive nature, inspired by the analytical stance described by i.a. Heath and Luff (1992) that conversation analysis adopts towards gathered and analysed data. This perspective is here interpreted to imply that no object or event, even if initially considered trivial, should be treated as irrelevant to the interaction between the participants. Seemingly irrelevant actions performed by the students during the gaming session are therefore considered in the analysis as well, things that are "seen but unnoticed". According to the researchers Garfinkel and Sacks (Heath & Luff 1992, 8), the "seen but unnoticed" resources are unavailable to unguided intuition, introspection, or theoretical imagination. As demonstrated in previous empirical

studies however, they can be made accessible through detailed analysis of an action taking place in its real context. Analytic attention should therefore be directed towards the accomplishments of the social actions that occur in an actual place, and towards the resources that the participants utilise to produce or coordinate these actions. The analytical attention in this study focuses on the actions that took place on the actual playground while playing the game.

The video data were transcribed in detail, and analysed in a two phase analysis (Patton 2002), without any predetermined categories. The system used when transcribing the data focused on students' actions, utterances, conversations, and interactions, and their interactions with the game and the handheld computer (including the interface and the GPS). As the transcription work was completed and data were analysed, a number of actions were distinguished and interpreted as the core actions. In the next step of the analysis, these actions served as categories for structuring the transcribed data. The data gathered under each category provided material to be used in the written description of the actions, and excerpts served as examples to emphasize the significance of the different actions. The actual process of interpreting data was viewed as a structuring activity, as an attempt to bring order and give meaning to the material gathered. Since the aim of this study is to focus on the action involved in a mobile gaming session, and not on the particular topics of the conversations between the gaming students, the actual content and the concepts of understanding that the students developed were not dealt with in this analysis.

Findings

When playing a mobile educational computer game, in conformity with almost any other human action, several actions take place simultaneously, separately or in conjunction with each other. The outcome of the analysis in this empirical study is a visual and written description of eight more prominent actions and sub-actions that occurred in all six student groups when playing *Agent O*. The actions identified are both those that emerged in direct connection to the actual gaming session, but also those that emerged in the situation as a whole: the social practice that the gaming took place within. The eight actions were alternately interacting with,

reinforcing, and/or preventing each other, as well as generating new actions during the gaming session. Jointly these actions created a web, with layers of actions that carried the overall action forward.

Eight Actions

The actions are:

1. Obtaining information/quests/instructions: receiving information from the game or from other gamers, reading aloud, watching video sequences and other pictures, gathering and exchanging documents.
2. Reasoning about the subject: discussions about the subject, game content and how to solve the case.
3. Role playing: taking on the role assigned to them in the game.
4. Discussing game technology: talking about the technology, GPS, handheld computers, graphical interfaces, etc.
5. Navigating: deciding where to go, pointing out directions, referring to both the virtual and physical playground.
6. Performing: actions related to the presence of the video camera, such as over-acting, showing off, making fun, referring to what ought to be filmed, etc.
7. Moving: between the different parts on the physical playground.
8. Talking beside game matter: bringing up and discussing issues irrelevant to the game.

Some of these actions seem to be rather obvious and basic when playing an educational computer game, such as actions 1, 2, 3, and 8. What makes this mobile gaming session different in comparison to other non-filmed, more traditional gaming actions taking place in front of a stationary computer in an indoor environment is the appearance of actions 4, 5, 6, and 7. These actions can be seen as specific for a filmed mobile gaming session taking place outdoors and involving this particular technology.

A Visual Overview of the Actions

The visual overview is a summary of the eight actions and sub-actions emerging during the gaming session. All actions relate to each other, but

the dotted lines indicate that some of the actions were more strongly interconnected.

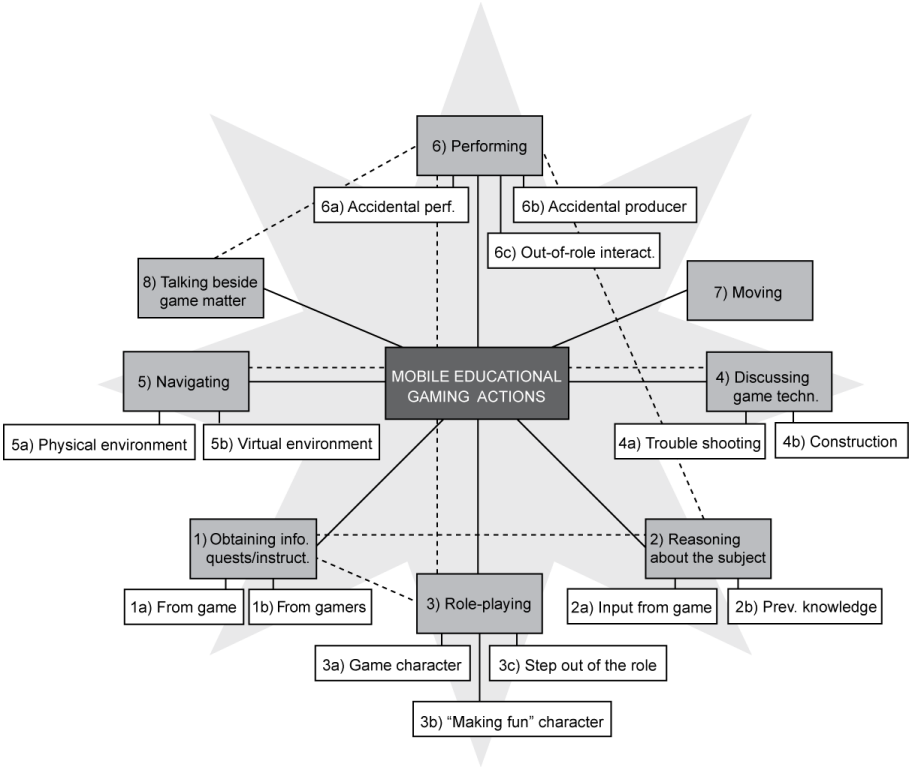

Figure 2. A visual overview presenting the eight main actions and sub-actions emerging when Agent O *was played by the students.*

Written Description of the Eight Actions and Their Sub-Actions

The students' utterances presented in the excerpts have been translated from Swedish into English by the authors. Lines in italics between quotation marks are information provided by the game via the handheld and which the students read aloud from the display.

Action 1: Obtaining Information/Quests/Instructions

To advance in the game, the students received instructions, clues and quests from 1a) the game (i.e. the interface of the handheld computer), depending on where they were located in the game and in the physical environment, or 1b) gamers in other student groups, by exchanging digital documents. The information received consisted mostly of text and still images but also of video sequences with sound. When the students reached a point in the game where they could access new text information, it seemed to usually be the person currently managing the handheld computer who read the text aloud for the others to hear (see Excerpt A, turn 199). In most cases, the rest of the students in the group listened tentatively, turning their attention towards the handheld computer, and sometimes also reading the text in parallel to the reading person.

As the game was played in bright daylight, the sun reflections on the display of the handheld computer seemed to be a recurring problem that obstructed the possibility to clearly see the information presented. Also, the sound from the video sequences seemed to be difficult to perceive, as the speakers on the handheld computer were weak, and as noise from the wind and surroundings were heard above it. The video sequences were sometimes played several times, in order to understand the complete message. The problems of apprehending the information provided via the handheld computer due to the surrounding circumstances were commented on by the students throughout the whole gaming session.

Action 2: Reasoning About the Subject

As the students were introduced to the case in the classroom, they knew from the start what kind of assignment they had taken on. During the game, they received quests and information from NPCs, or from digital documents that they picked up on different locations on the (virtual and physical) playground, or alternatively, from digital documents they had exchanged with other student groups. As the students accessed more information, they started to reason about what could have caused the illness, based on what they knew so far. When reasoning about the possible cause, they used both 2a) information obtained within the game (see Excerpt A, turn 200), as well as 2b) previous personal knowledge and experiences, achieved within or outside school (see Excerpt A, turn

202, 204 and Excerpt B, turn 188). They frequently made parallels to their own personal lives, by e.g. referring to when they themselves or someone in their families had been ill.

Excerpt A

199	B:	Yes
		"I definitely do not want to contribute to some kind of article where you write about a mysterious disease among the dogs in Malmö before we can be sure of the cause. We do not want to worry the public before our veterinaries have come up with some more test results. What I can tell you today is that we have found a number of sick dogs. Their symptoms are muscular and joints pain and fever."
200	A:	Just like
	B:	It's the same symptom
		It's, it's borrelia
	C:	Uh, o god, o god
201	B:	[Continues to read aloud from the screen] *"The first tests show that it can be borrelia"*
		It's the same disease
202	A:	[Takes over the handheld computer and continues to read] "… *but this stays between us until the test results …"*
		It's because borrelia can not be found in Skåne so in that case it must have come here
203	C:	Of course it can be found in Skåne, are you stupid or what
	B:	So, there is a connection between the dogs and the humans, that they believe that they are both suffering from borrelia
	A:	Yes
204	C:	Maybe it spreads via ticks

Action 3: Role Playing

As previously explained, the student groups were allotted one of these three roles: veterinary students, medical students, or journalist students.

When interacting with the other students groups during the session, they seemed to take their allotted role more seriously, and 3a) play their allotted role and refer to themselves as e.g. "We are the veterinary students". All of the groups clearly stuck to the role they were playing throughout the whole session.

On the other hand, within the groups, among the group members, they seemed to mainly use the role as a way to play around and 3b) make fun, for example by saying "We are agents" with an eccentric voice, or exhilarating their actions in one way or another. Some of the groups had a clear ironic touch on almost all their utterances, at the same time as they were taking on the assignment with a serious attitude. When playing the game, they seemed to constantly oscillate back and forth between the imagined game world and their own reality. They played their allotted fictive role, and at the same time referred to their own personal experiences (see Excerpt B, turn 188).

Excerpt B

186	B:	*".. the tick has fixed itself... these borealis bacteria are transmitted. The risk for being infected can be decreased by eliminating the tick. One can partly protect oneself from getting stung by a tick by wearing boots, long trousers and sleeves in areas were ticks can be found. One can partly…"*
		Oh, it's the same
		"The diagnosis is determined by the appearance of certain antibodies in the blood"
187	A, C:	Uhu, uhu [Exclaiming]
		Fuck
188	B:	My mom has had borrelia, and a girl in my class had it in the summer time, she got really high fever and such
189	A:	Yes, I've had it, I had 42 degrees
190	B:	God

A few examples demonstrate when students 3c) stepped out of the role-playing during the session, and recalled that they were playing a

game and had to adapt to and accept the framework of the game (see Excerpt C).

Excerpt C

292	B:	But, are there ticks in Kungsparken?
293	A:	Yes, there are
294	C:	But uh, what do you mean by that, they exist in the game
295	A:	Now there is, you see

Action 4: Discussing Game Technology

In some of the groups, the main part of the conversation dealt with the actual game platform used and the technology behind it (the GPS and the handheld computer). There were mainly two kinds of topics during these conversations: 4a) problem-solving and 4b) questions concerning the construction of the system. The first conversation subject, dealing with trouble shooting, was the most frequent one (see Excerpt D). This was because the technology did not work as planned, and a lot of time and efforts were spent on e.g. making the pointer on the screen connect with the GPS sender.

Excerpt D

60	G:	You missed it
61	H:	No
62	G:	No, update it
63	H:	Where do I update it
64	G:	There, yes
65	H:	No
66	G:	[Deep sigh]
		I've been running around for a while and then come back and

Cont'd.

Cont'd.

		then it has started to work again
67	H:	But what the hell, it said that I had already taken a blood sample

However, the non-functioning game technology was a source of frustration that the students seemed to handle with patience and persistence. Despite the technical problems, none of the groups resigned or handed in the handheld computers without trying to solve the assignment. When the technology functioned, the students seemed to have no major problems with understanding how to interact with the graphical interface or with the hardware. No fear of or resistance to the technology was observed.

The second conversation subject dealt with questions concerning the construction of the system, and the technology behind the tools (see Excerpt E). The explanations given by the students of how the GPS functions were based on previous knowledge, since no detailed information about its functionality was provided when introducing the game in the classroom before the gaming session.

Excerpt E

65	A:	Now it starts to move, now it seems to get it, now, when we started to walk
66	B:	It's very slow
67	A:	We have to update it when we are there
68		But you can see it anyway, somehow
69	B:	But it's not because it's windy
70	A:	Now when you can see
71	C:	Starting to get the signals right [Laughter]
72	B:	Yes, wave and such [Waving with the hand] in the air
		Is that, is that how it works
73	A:	No, GPS is via satellite so it has nothing to do with the wind
74	B:	Ok, that's why it takes such a long time

Action 5: Navigating

To access certain information or quests provided by NPCs, or to retrieve digital documents with information, the students had to move around in the physical environment to locate the virtual buildings and meeting places marked out on the interface of the handheld computer. As previously explained, the graphical interface is a map of the physical playground, illustrated by an air photograph of the actual area (see Figure 1). The virtual buildings that only exist on the virtual playground are also marked out on the map, indicating where to go in order to retrieve more information.

When discussing where to go, the students referred to the 5a) physical buildings/environments located in the area (the physical playground) that were visually presented on the map provided by the interface (see Excerpt F, turn 97). Parallel to this, they also referred to the 5b) virtual buildings/environments that only existed on the virtual playground (see Excerpt F, turn 95). The students mixed the physical visible environment with virtual elements, and moved in between these two layers. As they reached a virtual building, there was a sound from the handheld computer announcing that they had ended up at the desired place. It appears as if the students did not find it problematic mixing the physical and virtual elements. For example, they referred to standing in a virtual building, even though they were just standing on an outdoor field.

Excerpt F

95	I:	MAS, we're heading for MAS [Authors' note: MAS = a hospital, virtual building marked out on the map provided in the interface of the handheld]
96	J:	And MAS is located where?
97	K:	Beside the school [Authors' note: School = a physical building]
98	I:	Beside the school
99	J:	Beside the school, so we're heading back now, are we finished

As in any other situation in everyday life, when pointing out directions to others, the students used their hands to indicate where to go

(pointing, waving). Another additional strategy applied when negotiating where to head next was to use the map provided on the interface of the handheld computer to plan the next move and point out which path to follow.

Action 6: Performing

The fact that there were video cameras and film makers present in all groups during the whole gaming session seemed to have strongly influenced the gaming experience as a whole. Along the actual gameplay process, a film production also took place, which occasionally even was the main action. Some of the students were more aware of the filming than others, acting and showing off in front of the camera, playing along with the film makers. Others in turn corrected the film makers, reminding them that they should not interfere too much, and continue to just document them from a distance.

The presence of the video cameras seem to have contributed to the fact that some of the gaming students took on extra assignments and became 6a) accidental performers who were acting and showing off, providing action, and/or 6b) accidental producers who became involved in how and what should be documented (see Excerpt G, turn 134). Additionally, a third interaction related to the video camera was observed, namely 6c) the out-of-role interaction, generating spontaneous actions in front of the camera as a private person, such as looking into the camera and smiling, hiding behind someone else, or pretending to run away for fear of being captured.

Excerpt G

134	C:	You don't need to film all the time
135	Film maker:	Have to
136	A:	Yes, they do, it's their job
137	B:	He films like my father, he says like "what, what happened", and then he films down in the ground
138	C:	You are fucking filming the feet

Cont'd.

Cont'd.

139	Film maker:	That's the way to do it
140	C:	You can film my shoe, honestly
141	Film maker:	I'm just documenting

The accidental performer was most visible in different movements or grimaces in front of the video camera, but also through plain acting, almost like reading lines. This happened both spontaneously, for example like holding up the hand and saying "No comments" or with a theatrical voice bursting out "O, my god" or when being interviewed by the film makers, who themselves were taking on the role as TV reporters (see Excerpt H, turn 352). Knowing that they were being filmed seemed to inspire some students to go even more into the role-playing (see Action 3) part of the game (see Excerpt H).

Excerpt H

352	Film maker:	Hi, this is the reporter X [Facing the camera]
		We're here with X and are wondering how everything is going, any success?
		[Directing the microphone towards the interviewed student]
353	C:	Well, things are going pretty well, we're right now heading back to check out the meeting place
		We have the document, we need some help from the medicine student to figure it out
354	Film maker:	What if they don't want to help? [Facing the camera again to ask the question, then directing the attention back to the interviewed student again]
355	C:	No, well then maybe we have to beat them up [Laughing]
356	Film maker:	You better do that [Laughing]
		Well, that's lovely, we wish you good luck and we will check how things are with you again later on
357	C:	Thanks [Laughing]

Action 7: Moving

As previously mentioned, the students had to walk around in the physical environment to access certain information provided by NPCs, or to retrieve documents with information. Approximately half of the gaming session outdoors (45 minutes) was spent in motion (as opposed to standing still), see Figures 3 and 4. It might be suspected that the students were less engaged in the game during these rounds of walking (similar to when participating in a kind of combined open-air walking and quiz competition). However, examples from the empirical data showed that the students were engaged also in between the points in the game when they were moving around. They were for example constantly keeping an eye on the interface of the handheld computer, to make sure that the GPS was working correctly. They also had to keep track on where they were heading in the physical environment, even though this was probably not a difficult task for them, since they were familiar with the surroundings in the neighbourhoods of the school where the playground was located.

The two illustrations presented below (Figures 3 and 4) give a rough idea of how the gaming time was split between gaming actions in motion and standing still. The two chosen examples are film sequences from the longest continuous clips that were found in the gathered data material. The dashed lines in the illustrations symbolise the gaming process (oscillating back and forth between "gaming actions standing still" and "gaming actions in motion").

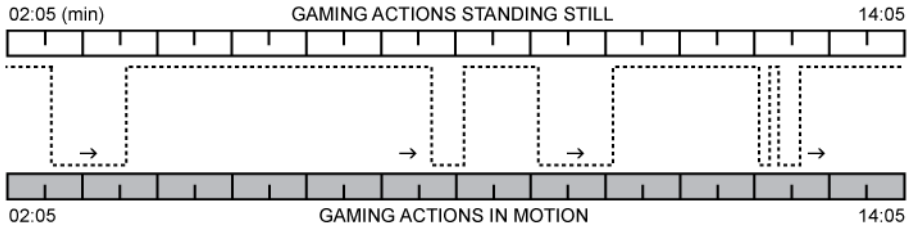

Figure 3. Actions performed by student group II during 12 minutes.

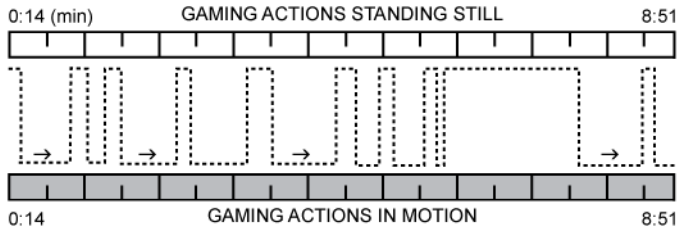

Figure 4. Actions performed by student group V during 8 minutes and 37 seconds.

In the first example displayed (Figure 3), the actions performed in motion occupied 1/3 (4 minutes) of the total gaming time (12 minutes). In the second example (Figure 4), nearly 60% (5:02 minutes) of the total gaming time (8 minutes and 37 seconds) was spent in motion. The two examples indicate that, on the average, half of the gaming time was spent walking around on the physical playground.

Action 8: Talking Beside Game-Matter

The irrelevant topics (with respect to the game) brought up were mainly practical issues, like the weather, time, hunger, etc. One exception was a conflict that started (and was resolved) between one of the gaming students and a film maker. This conflict dealt with personal issues and had nothing to do with the game, but obviously distracted the gaming action. The rest of the five groups were generally focused on the gaming actions related to the actual game, and did not enter into discussions irrelevant to the game. The presence of the video camera did seem to encourage some creative actions that did not really have anything to do with the game, but more to do with being noticed and filmed. These actions included, for example, dance moves and wall-climbing.

The Eight Actions in Relation to Each Other

The gaming session can be described as a multitasking/gaming session, with actions taking place in parallel, separately, or in conjunction with each other. To successfully play the game, the students had to keep track of several different tasks that had to be dealt with at the same time. Some

of the eight actions were obviously more tightly interconnected to each other (see Figure 2), such as trouble shooting (Action 4) and navigating (Action 5), since the technology was essential when navigating through the game. Receiving information from the handheld (Action 1), and reasoning about the case (Action 2), were tightly connected actions as well, since receiving more information and clues triggered the students to speculate about possible causes. Receiving information (Action 1) also triggered the role-playing (Action 3), since they were in fact playing the role as e.g. veterinary students interviewing a veterinary. To what extent receiving information (Action 1) made them engage in role-playing varied. The students also retrieved information (Action 1) without playing any apparent role, rather just mechanically reading the information, without any clear engagement in the role-play. When someone from outside the student group became involved, e.g. when exchanging information (Action 1) with other groups, the engagement and actions regarding role-playing (Action 3) seemed to increase.

Action 3 (role-playing) and Action 6 (performing) were also tightly connected, as the video camera created a "scene" in which to perform, and was perceived as an eye by which to be "seen". To be seen and be captured by the camera also triggered actions irrelevant to the game (Action 8), and a way of showing off or making fun. These actions could take on a physical character, but also come out as something more similar to an exaggerated performance. The presence of the video camera (Action 6) might also have influenced how students reasoned (Action 2), since the students knew that they were being documented, and therefore might suspect that their teacher would look at the film and see how well they performed.

Discussion and Concluding Comments

As demonstrated in the findings of this study, the situation in which people take action as well as the tools available have to be taken into consideration in order to understand what characterises a learning process. In this study, the situation in which the students took action was somewhat unusual in comparison to an ordinary school day, including the fact that they went outdoors, played a mobile educational computer game, and were filmed during the action. These three factors played a major role in

the process, along with the fact that a research team came to visit them. It also turned out that the chosen method for documenting the gaming students influenced the gaming experience to a great extent. The presence of the video camera triggered an extra layer of actions on top of the gaming action, and provided a scene for the students in which to perform.

When looking upon the overall gaming sessions from the outside, it might appear as if too many actions were going on at the same time in this multitasking/gaming session, and that this could have disturbed the students' attention. Nevertheless, the students managed to stay focused and fulfilled the mission. To be in a situation that provides space for different roles and parallel actions to occur did not seem to confuse the students, or make them lose their concentration. During the gaming session, the students were constantly oscillating back and forth between the imagined game world and their own reality. They were playing their allotted fictive role while at the same time referring to their own personal experiences. By moving in and out of the various roles as student, gamer and performer in front of the documenting video camera, the students became a sort of a student-gamer-performer-hybrid.

The findings indicate that the students identified themselves with the characters they were playing in the game, but on different levels and with different attitudes. Within the group, among the group members, they seemed to mainly use the role as a way to play around. On the other hand, when interacting with the other students groups, they tended to take on their allotted role more seriously. Some of the groups took on a clearly ironic attitude, making more jokes than other groups, while at the same time taking on the assignment with a serious attitude. Whatever role dominated the student groups at one particular moment, the overall goal stayed the same (i.e. to solve the case), although the motives for striving towards the goal seemed to vary with the role taken on. For example, motives for:

1. students could be to perform well, fulfil what is expected from a student in a formal school setting, accomplish the class and stick to the plan outlined by the teacher, obtain good results, etc.
2. gamers could be to explore the gameplay, solve the case and finish the game.

3. actors could be to perform a story and hold on to it, to use the gameplaying process and the framework of the game as a theme upon which to build a drama.

The students alternated between these roles, and as Facer *et al.* (2004), Rosenbaum, Klopfer and Perry (2007), Squire and Jan (2007) also found in their studies, this seemed to have contributed to making this an engaging learning experience. Instead of being driven by a single motivation force, the students had three sources of motivation to scoop from in case the desire to continue the mission dropped. As both Facer *et al.* (2007) and Squire and Jan (2007) experienced in their studies, and as Gee (2003) points out in his learning principles of what characterises good educational computer games,

> *[l]earning involves taking on and playing with identities in such a way that the learner has real choices (in developing the virtual identity) and ample opportunity to meditate on the relationship between new identities and old ones. There is a tripartite play of identities as learners relate, and reflect on, their multiple real-world identities, a virtual identity and a projective identity* (ibid, 208).

Some of the conclusions drawn from Facer *et al.* (2004), Rosenbaum, Klopfer and Perry (2007), and Squire and Jan (2007) suggesting that mobile gaming can be an engaging learning activity, are also supported by the findings obtained in this study. The positive influence of the physical playground and the ability to think and act physically and spatially, as well as leaving the classroom, seems to have motivated the students. This was expressed by their engagement when moving around on the playground. As also demonstrated in the presented excerpts A–H, it seemed as if the students felt personally embodied in the game, expressed by their verbal and physical engagement while gaming. Squire and Jan's (2007) statement emphasizing the fact that the learning takes place outside the "normal" classroom, as a combination of classroom culture and game culture, implied that the "pressure of grades and standardized tests were removed" (ibid., 22), can not be observed in or supported by this study. A speculation might be that the presence of the video camera

influenced how seriously the students took the assignment, since they knew that they were being documented, and that the teacher or someone else could watch them afterwards. Documented comments like "[a]re you not ashamed of being on film" referring to students fooling around, and "I filmed that, so now he can see that you are clever," might illustrate examples of this effect.

Let us turn back to the assumption that human actions, learning, and development occur in a socio-cultural context, implying that the learning environment (the situation) in itself is an integrated part in the learning process (Lave & Wenger 1991; Säljö 2005). One can discuss what this setting, consisting of a mix between a school lesson in science education, a gaming session and a film production, really added to the learning experience. This study can be seen as a clear example of the significance of the situation in which a game is being played, and suggests that the educational use of computer games ought to be seen as interplay between game, student, context, and teacher. According to the findings presented, the gaming actions seem to have primarily worked as a source of motivation for the students, and less as a way to access educationally relevant content. As emphasised by Arnseth (2006) and Facer *et al.* (2004) among others, computer games and gaming that are to be used in educational settings need to be contextualised in a way that enables the students to make sense of the educationally relevant content. As suggested by Facer *et al.* (2004), this could possibly be done through debriefing sessions, moderated by the teachers before, during, or after the sessions. Since the focus of this article has been to present an analysis of actions mediated by the mobile educational computer game *Agent O*, these issues have not been treated in here, but will be addressed in forthcoming studies when *Agent O* version 2.0 (inspired by the findings presented in this article) is released and played by new groups of science education students.

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Elisabet M. Nilsson is a Ph.D. candidate at the School of Teacher Education, Malmö University, and Malmö University Center for Games Studies. She is also enrolled in the Swedish National Graduate School in Science and Technology Education Research (FontD), and her research activities have a special focus on science and technology education.
E-mail: elisabet.nilsson@mah.se

Gunilla Svingby, PhD, is professor at the School of Teacher Education, Malmö University and co-founder of Malmö University Center for Games Studies.
E-mail: gunilla.svingby@mah.se

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