Dialogic Manifestations of an Augmented Reality Simulation

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In this paper we focus on the use of a combination of socio-scientific issues (SSI) and simulations. We have developed an augmented reality (AR) simulation called Transformer. The SSI narrative in Transformer concerns an electric transformer station situated in an area close to a planned new campus. Students' task is the issue if it is advisable to build a campus area. The simulation is organized as a role-play. The students take part in groups, playing one of five different roles.The aim of this study is to explore students' ways of using knowledge in relation to the AR simulation. We investigate how students integrate science and other knowledge in the debate constituting the final part of the role-play. The study is a part of a research process, guiding the researchers to further develop Transformer. The study showed that students justified their positions using scientific evidence and information collected through their own efforts outdoors in the real and actual environment where the AR simulation was situated. Students kept the controversy that existed between the different roles alive throughout the debate and stayed focused on the issue in question. We argue that this is due to the situated context achieved through the simulation.

Keywords: Augmented reality, design-based research, science education, socio-scientific issue.

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Introduction

The rapid developments of scientific knowledge and new technologies emerging in its trail have had a deep impact on modern society. Navigating as an informed citizen, society demands new skills to manage the implications of these technologies upon individuals and communities. Klopfer (2008) denotes sustained reasoning, managing complexity, testing solutions, managing problems in faulty solutions, organising and navigating information structures and evaluating information, and the ability to collaborate with others as twenty-first century skills. Formal education, in general, and science education, in particular, needs to explore new ways to engage students in meaningful practices where they can develop their reasoning skills integrating science concepts and processes, with social constructs and practices.

Vision II of scientific literacy (Roberts, 2007) emphasizes a broad approach to scientific inquiry using real- life situations where science components are embedded in situations influenced by political, ethical, societal and economic perspectives (Sadler & Zeidler, 2009). In line with this vision many researchers argue for the use of science-related social issues, socio-scientific issues (SSIs) to engage students in meaningful activities in science education (see Sadler, 2009 for a review). An SSI is often defined as an "issue" which has a basis in science and has potentially large impact on society" (Ratcliffe & Grace, 2003, p. 1). Other researchers (e.g. Barab et al, 2009; Foster, 2008; Klopfer, 2008; Squire & Jan, 2007) advocate games and simulations as engaging tools to immerse students at school in real life situations. In this paper we focus on the use of a combination of SSIs and games/simulations to engage students in sustained socio-scientific reasoning.

Games and simulations are two new and fairly undeveloped features in science education but according to Foster (2008) they have the potential to "..shape personal identity, make science activity relevant and meaningful, and show the applicability of science activity beyond school settings and for personal agendas presents situations for involvement, curiosity and understanding" (p. 610). Barab et al. (2007) use a virtual game (Quest Atlantis) to immerse students into a socio-science narrative. With reference to Gee (2003), they claim that well designed games have the potential to establish a sense of situative embodiment, that is a situation where students engage conceptually, socially and perceptually in a narrative where they have a legitimate role, and where their actions have consequence to the unfolding of the narrative. A situated experience is expected to deliver meaning to students' actions and propel them through the narrative, but the level of situatedness must be moderated at the design stage. Too much situatedness can prevent students from thinking outside the box and fail to transfer learning and experiences to other contexts (Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007). Earlier studies have shown how traditional computer games introduced in school with educational aims are more or less successful (Wiklund & Ekenberg, 2009). The term *gamer mode* is used to describe when the game construct an attitude among the students to achieve goals that are optimal for winning the game, but suboptimal with respect to educational objectives (Frank, 2012). This attitude is noted in relation to e.g. traditional computer games used in school with educational aims. One type of games put forward to reduce this attitude is augmented reality (AR) simulations (Squire & Klopfer, 2007). In AR simulations, learning goals can be tied to particular places and allow for embedded authentic resources and tools that are useful within the context of the simulation. Within these simulations, students interact with each other and with the environment around them.

Inspired by these experiences and recommendations, we developed our own locally designed augmented reality simulation called Transformer. The authors have described the design, testing and evaluation of Transformer previously (Lundblad, Malmberg, Areskoug & Jönsson, 2012). This study is in line with Cobb, et al. (2003) on design research:

> Prototypically, design experiments entail both "engineering" particular forms of learning and systematically studying those forms of learning within the context defined by the means of supporting them. This designed context is subject to test and revision, and the successive iterations that result play a role similar to that of systematic variation in experiment. (p. 9)

Cobb et al. (2003) says that design experiments are carried through to develop ideas about learning in specific contexts. These ideas are aiming at informing the teacher practice directly but should also be seen as a part of the design research since they guide the researcher how to develop the design experiment and plan next step in the iterative cycle. This study is the second step in a design based research cycle. The intervention combines socio-scientific issues (SSI) and augmented reality (AR) technology through a design-based research approach.

Transformer- an augmented reality simulation for high school

Transformer was developed by science teachers without any previous experiences of augmented reality simulations. The simulation is aimed for high school science students, and the narrative is based on an SSI concerning health effects from electromagnetic radiation emanating from a transformer station. In Transformer we used an augmented reality (AR) simulation platform where students use virtual tools to immerse in a narrative unfolding in the real world at their own campus (Lundblad et al, 2012).

Designing Transformer we used MITAR (Massachusetts Institute of Technology Augmented Reality), an editor for augmented reality simulations developed at the Teacher Education Program, Massachusetts Institute of Technology. The simulation is first designed on a computer with the editor and then downloaded onto smart phones used by the students. With the aim to develop a situationally embodied (Barab *et al*, 2007) socio-scientific curriculum we used the following parameters for the design: authenticity with strong local connection, spatial framing of the activity, definition of role characters, collaborative work with others in the process, ability to take measurements, and ability to make interviews with non-playing characters (NPCs).

The socio-scientific narrative in Transformer is situated in an area just outside the students' school buildings with the transformer station in between the buildings, fig. 1. This strong connection to students' everyday life is supposed to add meaning and relevance to the activity.

Figure 1. The location of the transformer station close to, and between two of the school buildings.

The area where the students can collect information is shown on a Google map displayed on the screen of a smart phone.

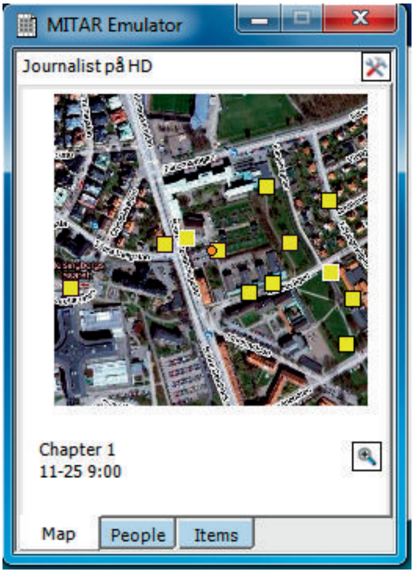

Figure 2. Smart phone screen view for the journalist with NPCs (quadratic dots)

Students' movements in the area are traced in real time on their screen. In the simulation, students adopt, in groups, one of five different roles: journalist at the local newspaper, chairperson of the student organization, technician at the city's Environmental Department, project leader at the power company, and engineer at the Swedish Radiation Safety Authority, each with a bearing on the issue in question. The students will discuss and resolve the main question face to face in a final debate where they act in their roles as protagonists for their perspective.

Three of the roles can take measurements of levels of the electromagnetic field at points decided by the students. In planning and evaluating their measurements they have to make use of both procedural- and conceptual science knowledge, which means that they both need acquaintance of how science knowledge is produced and knowledge of the science content. Interviews are preloaded in the smart phones and are designed to display different stakeholders' perspective on the issue in question. The perspectives of the different roles (local, municipal, national, and corporate) aim to give the simulation a socio-scientific content with inherent conflicts of interest.

The transformer station is surrounded by the school buildings. The school administration, at that time, was planning to connect the different school buildings with a campus area where students can spend their spare time. One of the reasons for this extension was marketing. This municipal school competes with a surplus of independent organisers in the city concerning new applicants to their programmes. The main question students address in Transformer is – *Is it advisable to build a campus area where students spend some of their school day so close to a transformer station, with high power cables emitting electromagnetic radiation?* Smart phones loaded with the augmented reality simulation were used. These phones with GPS guidance made it possible for participants to collect information in a confined area through fictional interviews, virtual measurements, and by their own senses of perception.

Aim and research questions

An aim with the study is to explore students' ways of acting and using knowledge in relation to an augmented reality (AR) simulation grounded on SSI (Lundblad et al. 2012). A way of considering science in SSI is to recognise the different types of knowledge, understanding and skills. The result will add to the growing field of knowledge of AR simulations in educational settings. In doing so we consider that the study makes a methodological contribution to the field. However, the study should also be seen as a part of a research process, guiding the researcher how to develop the design experiment and plan next step in the iterative cycle.

In this article we concentrate on the final part of the role play, a debate including all the students. We address the following research question.

> How do the students express the learning goals conceptual knowledge, procedural knowledge and values and beliefs in the debate? How do the roles differ in this aspect?

Method

This article is a part in a design based study where an AR simulation with SSI learning goals is developed. 20 students from a high school in southern Sweden participated in the simulation. The students attended the Natural Science Programme which aims at providing scientifically based knowledge of the conditions of life and of nature. Students belonged to a class of 32. In the outdoor part of the intervention, 24 players participated. Two of the players did not want to participate in the research part of the intervention, and two students did not participate in all parts. This resulted in a total of 20 participating students.

Their ages ranged from 18 to 19 years, whose background varies around a socio-economic average, coming from all parts of the catchment area. All students were beforehand informed about the research project. It was emphasised that their participation was optional and that they were free to change their decision whenever they wanted.

The whole activity lasted four hours with the AR simulation as the first of three phases of the intervention. During this phase the participating students were collecting information outdoors for one hour in the contested area using the simulation, mainly by observations, interviews and measurements. Phase two was two hours of indoor work in their roles, collecting additional information and forming their arguments. Here they used computers and the Internet to supplement their findings and write down their arguments. Phase three was a one-hour debate where students from the perspective of their roles argue for their standpoint and conclude by taking a vote on the issue in question. This phase was used by the authors to collect data for this article in connection to the research question.

Data collection

The debate, in which students in their different roles were arguing from their standpoint, was both video- and audio taped in full. The debate took place in an ordinary classroom with the 20 students facing each other grouped in their roles: journalists, chairpersons, engineers, technicians and project leaders. In the first part of the debate, the different roles had the opportunity to state their arguments. The first part was followed by 40 minutes of open discussion. The whole debate lasted for 65 minutes. The entire debate was recorded, transcribed and organised in chronological order with a label identifying each student and his or her role. In the quotes, the following abbreviations were used: *J* for journalist from the local newspaper, *C* for chairperson from the student organisation, *T* for technician at the city´s Environmental Department, *P* for project leader at the power company, and *E* for engineer at the Swedish Radiation Safety Authority. We used numbers, e.g. J1 and J2, to separate different students in the same role.

Data analysis

The first analytical step was to identify how different types of learning goals (knowledge, understanding and skills) are embedded in students´ statements. This was done by using classes from Ratcliffe and Grace (2003). They use three main classes: *Conceptual knowledge*, *Procedural knowledge*, and *Attitudes and beliefs* with a content described below.

Conceptual knowledge: students can demonstrate understanding of science concepts and the nature of science endeavour; the scope of the issue on personal, local, national and global level in both a political and a societal context and the nature of probability and risk and environmental sustainability attached to decisions in the issue.

It can be illustrated by utterances as: "/…/could be dangerous with this kind of radiation /…/" (J2), and "The limit for health risks is 0.2 radiation units, but there is no direct danger unless it is 50 times that value." (E1).

Procedural knowledge: students can engage in processes of decision-making using a partial and biased information base; cost-benefit analysis relevant for the issue; evaluation of both quantitatively and qualitatively presented evidence; and ethical reasoning deciding on issues of right and wrong as applied to people and their actions.

The following utterance illustrate procedural knowledge: "/…/ you use the transformer station to decrease energy losses during transportation of electricity from e.g. nuclear power plants to the city? If that´s so, then it might only mean that you move the problem?" (C1).

Attitudes and beliefs: students can clarify personal and societal values and ideas of responsibility and recognize how values and beliefs are brought to bear, alongside other factors.

In this utterance one student is using economy as an argument to bring forward his own values: "But to move the station would be unreasonably expensive."(P1)

We have used these predefined classes as an analytical lens to explore how different types of knowledge, understanding and skills are expressed in the debate as a whole and for the different roles.

We believe that this qualitative study can be useful in other settings, despite the inapplicability of statistical generalization. In line with Stake & Trumbull (1982) we argue that the feeling of personal knowing and experience is what leads to improved practice. That is, qualitative research provides readers with other people's experience. Through what Stake and Trumbull call naturalistic generalizations, readers can make choices that are based on their own understanding of the matter, rather than feeling as though the research report is instructing them what to do.

Results and analysis

The debate was organized in the following way: In the first part of the debate the students deliver a standpoint from their role´s perspective on the issue in question and their arguments substantiate this standpoint. This is called *presentation of standpoints*. The second part, here called *discussion between groups*, deals with the open discussion where students, in their roles, question each other´s arguments and at the end take a vote on the issue in question.

Presentation of standpoints

This episode can be characterised by turn-taking, i.e. reporting standpoints without questions or interruptions from other students. The following extract illustrates both what sources of information students use and different scientific knowledge.

> J1: Yes, we have been walking around and interviewing people, both students and people living nearby and also teachers and leaders for the whole campus. Actually, it is common for all students they don´t know much about this transformer station.
> J3: Yes all students. And then the teachers, it was quite common that they were worried, first and foremost for themselves since the students go to school for only three years but they can work here for a much longer time and they think that they are exposed to a much greater risk than the students.
> J2: Those living nearby are also uninformed in a way. They know that there are those who tell that it could be dangerous with this kind of radiation but there are also those who speak against this. They don´t know what to believe.

The journalists refer to NPCs (non-playing characters) – students, teachers and those living nearby - as sources of information. The journalists express worries from them in relation to their exposure to the radiation. In the following excerpt J1 combine statements from two different sources related to the AR simulation.

> J1:...we can take a quote from the homepage of the Swedish Radiation Safety Authority (SSM) "since health effects from magnetic fields from power lines in the long term can´t be excluded the Swedish authorities has chosen to recommend certain cautiousness both for the public and the working life." But the chief of city planning means that you don´t have any direct knowledge of the danger from this radiation so it´s a too big project, financially to physically move either the campus or the transformer station based on the evidence we have today. He draws a parallel with the street nearby with a lot of traffic every day and this is harmful for people; but it´s such an important route in this town so you can´t just move it.

In this quote the voice from one NPC is meeting a conflicting standpoint from a homepage, showing the complexity of the issue. We can identify how both *conceptual knowledge and procedural knowledge are expressed: science concepts* - magnetic fields from power lines; *scope of the issue* - both local and national authorities are involved; *probability and risk* - valuing the dangers from nearby traffic; and *cost-benefit* - moving the campus, transformer station or the through route. The students are not giving a simple and straightforward answer. Rather, through letting different groups of interest meeting each other, they consider many influencing factors and perspectives from both a scientific and a societal point of view.

Students acting as chairperson of the student organisation (C) use sources from NPCs and homepages.

> C1: Yes and SSM has on their homepage information telling that you should avoid placing preschools and schools close to transformer stations where children are.
> C2: You don´t know if it will affect you in the future; you can get cancer from it, which is why they think you should act on the safe side and avoid it. You can´t say for sure that you get cancer from it or not, but it´s safest not to build a campus or build houses around the transformer station or anything that emits electromagnetic radiation.

The risk of child leukemia connected to living close to power lines is put forward. There is no undisputed scientifically established connection between power lines and child leukaemia so the chairpersons have to deal with conflicting evidence in their decision-making. They use *procedural knowledge* when they *evaluate scientific evidence* concerning child leukaemia and furthermore *values and beliefs* when they consider *ethical questions* about responsibility towards other students they represent. We can also identify *conceptual knowledge* when students are balancing *probability and risk*, they adhere to the precautionary principle and so far in the debate decide to argue against the campus area.

In relation to the design parameters both journalists and chairpersons refer to information collected from NPCs and homepages. It seems as the conflicting views help them to understand the complex situation with different stakeholders and conflicting evidence.

The other three roles met fewer NPCs. However, they had the ability to take measurements of radiation levels all over the contested area. We exemplify this with an excerpt from the engineers (E) at SSM.

> E1: The limit for health risks is 0.2 radiation units, but there is no direct danger unless it is 50 times that value.
> E2: The highest value we got was just in front of the transformer station, where we actually never are. There we got 20.9 which is terribly high; and we only got it there. Then we got readings that were at 0.7 as the highest. This was by the N-building over in the corner. It is elevated, but it involves no risk.

The engineers argue quite different in relation to journalists and chairpersons. They expose a strong science identity using references to measurements they have made themselves on different places in the area. From oth-

other quotes we can say that the references to NPCs are few. Information about the threshold value of 0.2 radiation units was given in the simulation to the three roles with measuring capabilities. This value is undisputed by the students and treated as an objective scientific fact. None of the roles with science identity questions its origin and reliability. In planning, conducting, and evaluating their measurements they used both *conceptual and procedural scientific knowledge*.

The three roles with measuring capabilities use many references to measurements they - and others - have done. They use threshold values when talking about risks for people in the area. In contrast to journalists and chairpersons, they use almost no references to information from interviews with NPCs. They are focused on evaluating evidence from 'objective information', accepting them at face value.

Discussion between groups

The second part of the debate was an open discussion in which students questioned each other's arguments. There was no time for them to prepare their utterances, and they argued more spontaneous in this part of the discussion compared with the first part.

> C2: I have a question to E2. Have you thought of sources of errors in your measurements? You have only taken measurements in certain areas; can there be any possibility that there are elevated values in any other areas closer to school?
> E2: No, if there were any sources of errors they would be very small and not affect our results. We had no value close to the threshold value, so it doesn´t matter if our values are a little higher or a little lower really, since we were not in the vicinity of the school.
> E1: We have taken measurements around school also to cover the whole area.
> E2: We have taken measurements on 10 locations, and they´re accurate measurements; we know what we are doing.
> C2: Is there any possibility that values in the future will increase even more, or?
> E2: No, it radiates just as much all the time. It´s not that it becomes more or less. It´s the same all the time.

In this dialog the students use both *conceptual science knowledge and procedural knowledge: they* discuss systematic collection of data, value the measurements critically, discuss the nature of the radiation and connect this to possible risks in the future and evaluate evidence. When questioned and without time to think things through, E2 gives an incorrect answer to C2. The amount of radiation is connected to the current in the power lines. A higher energy outtake generates higher currents and, in turn, higher radiation

levels. C2 acts more penetratingly. We can identify *attitudes and beliefs* when they are trying to explore any biases in the engineers´ arguments and, *express ideas of responsibility* to future stakeholders whilst the engineers act more defensively relying on their measurements.
In the next excerpt the chairperson of the student organization (C) uses *conceptual knowledge:*

> C1: I´m just thinking of the fact that this city is growing and expanding. There are plans to rebuild the harbour into houses and then the need for electricity will increase, of course, since there will be more houses and then maybe the power company decides to expand this station. Maybe not spatially but to a higher capacity; and then maybe these values increase substantially; we don´t know that, but they can decrease too. Then, suddenly the campus area could be a dangerous place and we are caught with `our pants down´, since we have invested x number of millions.

C1 expands *the scope of the issue* by bringing in factors from outside the campus area using information from the media and other sources collected outside Transformer. He brings forward *probability and risk* tied to future consequences, an element of *cost-benefit analysis*, and he *clarifies societal norms (attitudes and beliefs)* of a safe and economically sustainable society.
Later, the discussion circles around possible ways either to move the transformer station or to build some kind of protective shelter around the station. This is exemplified by a part of the episode in which the chairperson from the student organisation (C), the project leader at the power company (P) and the engineer at the Swedish Radiation Safety Authority (E) take part:

> P1: I would say that instead of moving this station I must insist on that it would have been much cheaper for us to build some kind of protection even if it doesn´t help that much. The values aren´t that high, so it doesn´t have to help that much. But to move the station would be unreasonably expensive. So, to put up a protection would be more feasible for us.
> E1: When you say this about moving the station. It has to be moved somewhere. And there will also be people living there. There will be people passing by. And to build a new, bigger station will only contribute to even more radiation moving longer away, reaching more places. It is much smarter to have many small stations than one big one, because then the radiation becomes huge in that area. Because wherever you place the station, there will be radiation; it´s inevitable.
> C1: Well, I'm not employed at the power company, nor am I a physicist or anything like that, but isn´t it the case that you use the transformer station to decrease energy losses during transportation of electricity from, e.g, nuclear power plants to the city? If that´s so, then it

> might only mean that you move the problem, because you need to have a station close to where people live to make it cost-effective. Then we have the environmental point of view also, and I don´t know how all this connects; but it´s just my opinion.

This excerpt shows how the students argue free from the sources of information in Transformer. The idea of moving the station and how this will concern people and the environment in the future is connected to *sustainable development*. Students use *conceptual knowledge* when discussing issues about how to transport electricity and the propagation of radiation. Balancing the costs of moving the station against values of safety and talk of placing the station in a cost-effective distance from people is a *procedural issue*. They also express *societal values* of a safe, effective and cost-efficient society.

To sum up; all three knowledge classes appear frequently in the debate. Statements with conceptual and procedural connections to science are more frequent than those dealing with attitudes and beliefs. The most frequent topic was evidence evaluation from the procedural learning goal and the least frequent was ethical reasoning from the same goal.

Pertaining to sources of information used during this episode, references to NPCs almost disappeared. In the open discussion when they reasoned, taking into account a broader perspective on power supply, societal- and environmental effects of the transformer station, they used much information from outside Transformer. Statements with references to measurements were as frequent as in the episode *Presentation of standpoints*.

Comparing the two parts of the debate, we see that in the first students present their main arguments based on their collected evidence and information without much interference from the other roles. In the second episode the conflicts of interest between the roles are brought to bear on the issue in question and different roles argue much more, questioning each other´s arguments and discussing possible alternative solutions to avoid being exposed to radiation from the transformer station.

Differences between the roles

The intentions at the design level were to create roles elucidating views from different societal levels with conflicting interest: a) the chairperson representing the local level, with knowledge and feelings for the immediate surroundings, b) the journalist acting on a city level with beliefs and concerns for the inhabitants of the city, c) the project leader acting from a business perspective representing a company with an interest in making profit, d) the engineer representing the national level governed by legislation and international treaties and e) the technician looking after the local environmental problems and risks.

Two trends emerge. The first is the difference in how roles with and without measuring capabilities express themselves. Both the journalists and chairpersons involve more perspectives into their arguments, weighing them against each other.

> J1: There are some research that indicates that there are risks and some research contradictory. With this in mind, it is not so that one should not have a debate because they level out anyway. Here we have one side that says that there could be risks and there are children and people in the area we are talking about. I definitely think it is cause for a debate, maybe even a cause to move the transformer station. And then I think you must check the plans behind the campus area. The plans are that the different school houses will be more integrated with each other; students will move around more in the area, and they will move between the different buildings.

The journalists and chairpersons also act more critical than the other three roles, confronting the others with challenging questions thereby forcing them to clearly justify their arguments. They immerse in their role quite strongly. The three roles with measuring capabilities also immerse in their roles, but they argue much more using measurements they have made, values, measuring strategies, threshold values and the consequences from these.

> T1: I also thought of that. If the threshold values decrease or if the values increase, the students would have been forced to move. Since if they had been increased up to 10, then there would have been a risk being in the area generally, and then it would have been impossible for us to be here.

The technician at the city´s Environmental Department (T) shows a much narrower defensive and less sceptical focus compared with the other two roles.

A second trend, coinciding with the design intensions regarding different, and sometime colliding, perspectives, emerges between roles with measuring capabilities. Technicians, with responsibilities towards the inhabitants, argue more using the concern for people around the station compared with the other two. Project leaders focus on factors affecting the company and engineers focus on measurements and threshold values referring to national and international standards in constructing their arguments.

Discussion

When acting in the debate, students argue using sources of information from both the resources in Transformer and information from the wider sociocultural dimension, e.g. from public debate in media and other sources from the web. Sources inside Transformer are preloaded static information from texts and interviews and more dynamic information from measurements. These are the main sources used in the prefatory phase, in which each role delivers their standpoint. In the second episode, features of external sources, such as common knowledge and knowledge of the local environment, become more evident. Independent of the kind of sources used by the students, they are focused on the issue in question. Almost every statement has relevance to the issue at stake. This, we argue, is due to the spatial framing, collaborative work, and the authenticity and strong local connection of the issue. Students are augmented by reality (Beckett & Shaffer, 2005), and the augmented reality simulation is essential as the glue that holds these parts together and generates the students´ narrative embodiment in the issue. Students' statements in the debate give evidence of the *situative embodiment* defined by Barab *et. al* (2007).

> Situative embodiment involves more than seeing a concept or even a context of use; it involves being in the context and recognizing the value of concepts as tools useful for understanding and solving problems central to the context in which one is embodied. (Barab et. al, 2007, p. 2).

Students formulated hypotheses about the impact of the transformer station, collected and valued evidence to test their hypothesis, assembled their evidence to form an opinion, and argued for their standpoint in the debate using knowledge from the three learning goals (classes) of SSI as defined by Ratcliffe and Grace (2003). The complexity of the different stakeholders' values in the issue is expressed in the debate. Students' active participation in the role mirror the social practices of decision-making in a democratic society (Sadler, Barab & Scott, 2007), which may be transferred to future involvements in similar processes outside school ´in real life´ as proposed by Sadler (2009).

The character of the roles is an essential part in the design of a socio-scientific issue. The different roles must be appreciated as important for the issue in question and represent different perspectives and values to generate a controversy typical for an SSI (Ratcliffe & Grace, 2003). Students in Transformer accepted the roles as actual and relevant to the issue in question and immersed in a consequential form of embodiment (Barab et. al, 2007) acting as protagonists for their role perspective. We used the simulation to frame and balance the narrative and gave the students space to propel the narrative by themselves. In doing so, specifically three roles —engineer, project leader and technician —made the students position themselves as "scientists". Playing these roles students mainly referred to measurements and threshold values and were accepting these as objective facts, which they didn't question. The roles journalist and chairperson, made the students position themselves as critical towards presented information and valued it more thoroughly. They also brought different sources into their arguments and challenged their opponents with demanding questions.

The positioning in relation to the role is likely to be a reflection of students' preconceived notion of how scientists, journalists etc act. However, we believe that this polarization of roles is a prerequisite for a debate in which many different opinions can be heard. This is in line with Mercer & Littleton (2007) who write that when conflict arises through critical commitment to the issue then more meaningful learning is likely, compared to discussion where there is agreement between students. Letting students engage in discussions that can create conflict, diverse knowledge and experiences may facilitate more effective learning in these situations. The polarization is further emphasized by the conflict of interests that exists between the different roles, each role acting as protagonist for one area of interest of the issue in question. Every piece of information brought in from sources outdoors the simulation was relevant and contributed to the debate. We argue that this is due to the situative embodiment achieved through the AR-simulation.

According to Sadler and Donnelly (2006) students have some difficulties in tracing the science in an SSI and especially using their school science in constructing an argument. However, in this AR-simulation students used both science concepts and procedures in constructing and delivering their arguments.

We argue, in line with Sadler (2009) that an AR-simulation concerning an SSI creates opportunities for students to engage in a socio-scientific discourse.

> I am proposing that an important objective for science education ought to be for learners to come to identify themselves as willing and able to engage in socio-scientific Discourses. As such, learners come to position themselves as active contributors to society with competencies and willingness to employ scientific ideas and processes, understandings about science and social knowledge (e.g. ideas about economic and ethical influences) to issues and problems that affect their lives. (Sadler, p 12)

Implications

Engaging students in activities like Transformer is well in line with the new syllabus for the Natural Science Programme in Sweden (SKOLFS 2010:14, 2010). According to this document, students are to be given the opportunity to develop ability to evaluate different types of sources and to know how to separate statements based on scientific grounds from those based on nonscientific grounds. Their abilities to think critically, solve problems, make systematic observations, and to participate in discussions delivering arguments are to develop during their education. Activities like Transformer can be used both to train students in these abilities and as an assessment tool (Hickey, Ingram-Goble & Jameson, 2009) to explore how well these abilities have developed.

Using AR-simulations in science education has, as we see it, three immediate advantages. Firstly the possibility to make virtual measurements bypasses the often tangled process of achieving reliable values of science concepts. Instead of handling expensive and complex instruments, students in Transformer can focus on the results of their measurements and the circumstances under which they were made. We do not deny the importance of educating science students in handling instruments, but we believe that it is at least equally important to learn how to situate the results in a broader scope than the science classroom. The second advantage is in concordance with this. In an AR-simulation, the environment outside the classroom is a natural prerequisite. The second advantage is in concordance with this. In an AR-simulation, the environment outside the classroom is a natural prerequisite; building on mobile technologies and GPS guidance students explore the real and actual outdoor environment making observations and measurements, which is seldom the case in contemporary science classrooms. The third advantage is that using an AR-simulation in SSI curricula is time efficient. Transformer, with its three phases, was concluded in a normal school day, including lunch break. SSIs are normally quite time consuming and lack of timetabled time is a serious constraint in teaching SSIs (Oulton *et al*, 2004; Sadler, Barab & Scott, 2007).

Designing Transformer and implementing it in a natural setting is just one stage in a design based research cycle. In forthcoming cycles, we plan to use new mobile network techniques to achieve a more dynamic simulation, where information and circumstances for the different roles can be changed during the simulation.

Acknowledgement

We would like to thank Eric Klopfer and his associates at the MIT Teacher Education Program for both inspiration and technical support in the development of *Transformer*.

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