Learning Games as a Platform for Simulated Science Practice

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ABSTRACT
In recent years, science education has been the focus of study and development of new game-based learning environments. It has been argued that active and critical learning about rich semiotic systems, learning through learning communities and the complex problem-solving that good games involve, resemble science learning as being an active process of inquiry just as real life science practice. In this paper, I present the first studies from a test of the cross-disciplinary science educational game 'Homicide', a forensic investigation game developed at Learning Lab Denmark. The goal with Homicide is to use the game media to simulate an 'authentic' learning situation of science experts. In the game the players go through the process of inquiry similar to that of forensic experts. In this paper I present the first observations from a play test of Homicide and discuss the potential in this type of game-based learning spaces.

Keywords
Learning games, science education, game-based learning.

INTRODUCTION
How computational media can change science education has been an object for discussion for several years (diSessa, 2001, Resnick, 1997). The claim in this work is that computers engender a new literacy and that the new representations computational media allow can transform science education (diSessa, 2001). This has lead to new designs of digital learning environments based on the notion that meaning is material, situated and embodied and that abstract systems originally got their meanings through embodied experiences (Gee, 2003, diSessa, 2001).

Science education has in recent years been an object of study and development of new game-based learning environments (Klopfer & Squire, 2004, Barnett, 2004). It has been argued that the active and critical learning about rich semiotic systems, learning through participating learning communities and the complex problem-solving that good games are theorized to involve, have much in common with science learning when understood as an active process of inquiry as familiar from real life science (Gee, 2003, Gee, 2004). Traditional science education has been

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criticised for being based on memorisation of facts and for creating little ownership and practical understanding of the scientific process and methods (Gee, 2003, diSessa, 2001). Relatively little is known about how learning occurs through game-play, or about the interaction that occurs when complex game-based learning environments are brought into a school culture (Squire, 2004).

The digital game media are well suited for simulating complex rule systems and real- life settings. It is a medium suited for complex simulations integrating many different aspects of real-life learning environments and framing them in a graphical simulation the player can identify with and relate to. Accesses to a wider range of powerful representations support authenticity and make it possible for players to tackle 'real' problems and their attendant complexity and difficulty. Thus when creating new game-based science learning environments, it is interesting to consider how we may use the game media to simulate science practice.

This type of game-based learning space is based on the notion of situated learning, but being a simulation of a practice it is not learning in situ in the authentic context the simulation is based on (Lave & Wenger, 1991). The basic argument is that communities of practice are everywhere. The types of game-based learning spaces described in this paper are specifically designed to bring 'authentic' science practice into the classroom. In this paper I define this type of learning spaces as a 'simulated situated learning space'

In this paper I present the game 'Homicide' which was designed for cross disciplinary science education (Magnussen & Jessen, 2004). Homicide is an IT-supported role-playing game where students play forensic experts solving a murder case. This game-based learning environment was designed to develop science competencies through a simulation of a praxis learning situation. I will provide an introduction to the game and first studies of Homicide 'in action', and I shall discuss the elements and perspectives of this type of game-based learning space.

The Game Homicide

Homicide is an IT-supported role-playing game where players play forensic experts solving four different murder cases. The game takes a week of school to play through and is organized as a combination of work in investigative groups (each working on their case) and meetings where groups share information about their individual case and are encouraged by the chief of police - the teacher - to set new goals in their investigation. The game ends with the groups presenting their theory to the other teams and writing an indictment based on the evidence and testimonies of suspects and witnesses. The interaction in the game is primarily between the students in the classroom and not a computer-student interaction as seen in most traditional computer games.

Figure 1: Interface, the game Homicide, the policeman's desk is.

The games' interface provide the players access to videotaped interviews with 'suspects', reports from the local police, maps and pictures of and information about evidence found at the crime scene. In the investigation process the investigators analyze the evidence through laboratory work and analytical processes using technological and scientific theoretical and practical analysis methods that are available in the Forensic Handbook. Examples of these investigation processes include chemical analyses of samples from a suspect's hands to determine whether that person has gunshot residue on his or her hands, which would indicate that the suspect has fired a gun lately; and measurements of shooting angles to determine the height of the shooter. The students have to handle different types of data and use different types of skills including critical thinking when they analyze interviews with the suspects and empirical competencies in handling the data from the technical investigations.

The educational goals of the game are closely integrated in the fictional investigation process. The overall educational goal in the game is that it should support working with, and learning of, the process of inquiry as the basis of scientific investigation. The process contains different steps; problem definition, establishing hypotheses, conducting investigations, making observations, collecting data and explaining results. The methods used to solve the murders, the chemical tests et al. are or appear authentic (or as close to authentic as was possible). Authenticity is both an educational tool, making the skills and knowledge easier to transfer to a realistic situation or perspective, and an artistic effect. The students have, of course, seen movies and read about police work, and the games' authenticity furthers their motivation.

Homicide 'in action' - playing the murder game

We have conducted two initial one-weeklong studies of two eight grades as they played Homicide. These studies are the first of a larger planned experiment-based study aimed to investigate how the social context in schools' science education correlates to the game design and how we can integrate design and the social learning situation to create a game-based simulation of science practice.

Each of the studied classes played the full version of the game and the game was orchestrated by the classes' science and language teachers. We conducted video observations in both schools, documenting the investigation practices of each group and focusing on direct interaction in the pupils process of inquiry (Stigler & Hiebert 1999). We paid special attention to the pupils'

practice at the different stages of the process, examining how the first hypothesis about possible suspects and actions in their cases was formulated, what tools and actions was applied in the analysis of the data that was generated in the investigation process, and the pupils' argumentation in formulating a final theory. We also conducted a twenty-minute focus-group interview to probe the pupils' experiences in order to document their thoughts and feelings towards the game situation and their own understanding of the investigation process. In spite of the fact that the studies presented here are early results in an ongoing study, they present a picture of some of the processes that takes place in a game-based learning environment as Homicide.

The general observation in the class was that the game created an intense learning situation where the pupils organized work in the groups, created tools for the investigation process and actively discussed problems among the groups. In the following section I describe examples of two types of situations that are representative for the typical learning game situation in the class: 1) the creation and use of tools in the inquiry process and 2) examples of how pupils learn from each other.

Creation of diagrams to use as investigation tools

Early in the game, pupils started producing different types of diagrams to systematize the inquiry process with data collection and analysis and generation of hypotheses. In the game material there is an example of how to create a gallery of suspects in the case, but the pupil's diagrams differs in design and content (see the two pictures bellow). With the aim to study the pupils' inquiry process, these tools and the social interaction around using and creating these tools became the focus of our attention.

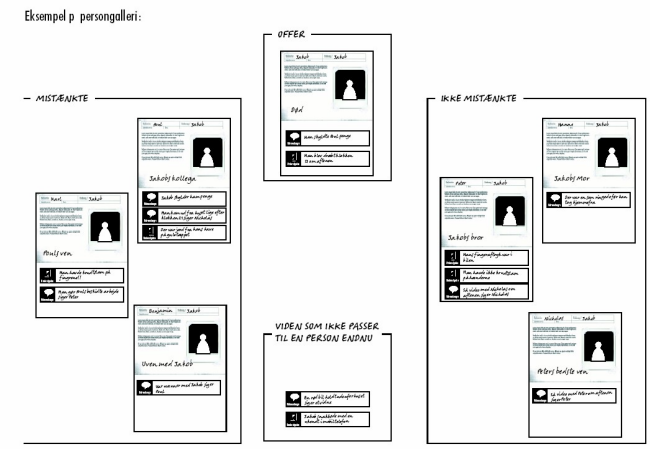

Figure 2: Example from the game material of how to create a gallery of suspects

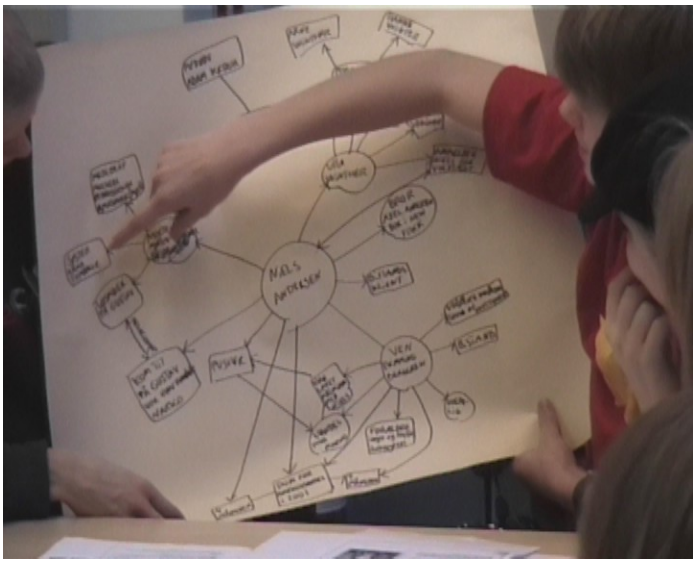

Figure 3: Boy using a diagram for presenting his case.

The following is an example from the initial phase of the game in one of the classes. A group have independently created a diagram and used it in their presentation of their case.

> Boy: 'We have Niels Andersen here (points to a circle with the name in the centre of the diagram) who was killed. And here are… everybody is under suspicion. Flemming Berggren is under suspicion. Morten Møller and Ulla Winther (points) and this are the three people that are the most under suspicion. And Niels Andersen is a pusher and he has been involved in crime with his friend Flemming Berggren (points) and they have probably – this we don't know yet – but they have probably been dealing drugs together because they were convicted in 2001 for dealing drugs (points).'

Rather than creating a gallery of suspects by mounting pre-produced posters on a wall, the students independently redesign the tool that is offered in the game. In the diagram produced by the group, the murder relations to the suspects are represented by lines between boxes. The suspects are represented by square boxes with names. These boxes also contain information about occupation and earlier convictions. After the presentation, the rest of the groups in the class produce similar diagrams, but with different designs such as colour codes for representing different types of information. Some groups extend the use of the diagram by including knowledge about possible motive.

Students both use diagrams as representations of their knowledge, for presenting their work at meetings, but also as a working tool. In this example a boy and a girl use the diagram for discussing a case in which a young accountant, Marie Johansen, has been found dead. The boy and a girl go through the information they have access to using a diagram they just made. The girl point at the diagram while the boy writes down the information she gives him. At this point in the game, they have found out that Marie was having an affair with her boss, who is also her

sister's, Anne Berg's, husband. Jens Kaspersen is a colleague to Marie.

Boy: Next is Jens Kaspersen

Girl: Jens Kaspersen. They both worked in the same company. And Marie Johansen was promoted, probably because she had a sexual relationship with the boss. Jens Kaspersen said so. And once Marie Johansen is dead and all this is over, he'll get her position. And that makes him a suspect, I think. But Anne Berg too…

Boy: We aren't trying to solve the murder right now.

Girl: No, but she said that Marie deserved the promotion because she was very good at her job and very dedicated. That could be because she doesn't want to seem suspicious.

Boy: Yes, to confuse us.

Girl: She might not know of Marie's relationship to her boss. So I think we should examine the footprints [near where the body was found] to see If they were made by a man or a woman.

In this example, the pupils used the diagram as a tool in forming a hypothesis, interpreting knowledge from interviews and crime scene evidence, and outlining a method with which to test it. The footprints may or may not support the theory that Marie Johansen was murdered by her sister, Anne Berg

Representations of the inquiry process

Diagrams are also used as a tool to represent knowledge at different stages of the investigation process. One example of this is this group that creates new diagrams as their work progresses.

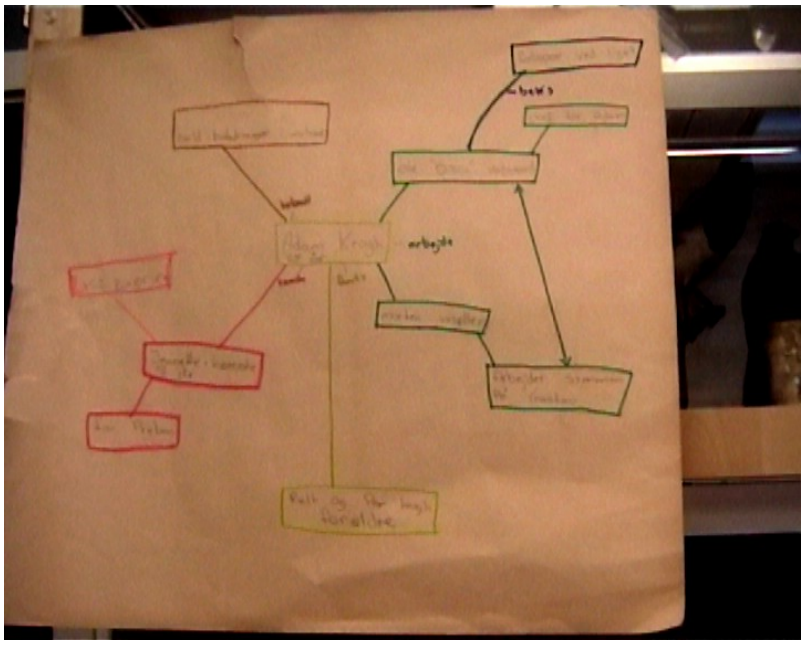

Figure 4: Diagram A was created in the initial investigation phase and contains information on all the suspects in the case and their relation to the deceased

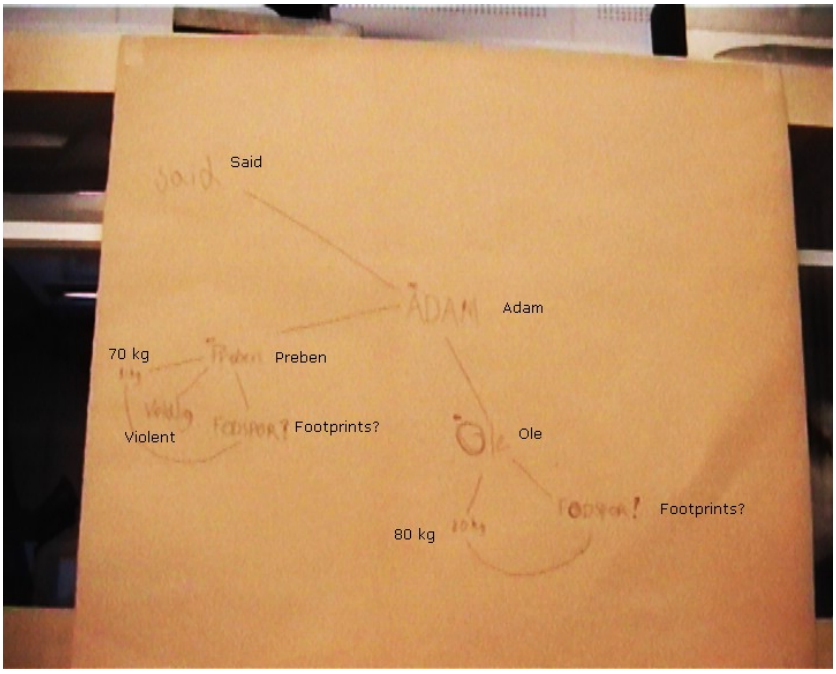

Figure 5: Diagram B was created in a later phase of the game and only contains information about the three crown suspects Said, Preben and Ole

Diagram A was produced early in the investigation process and contains all the initial information about the murder victim, Adam, and his relations to all the suspects in the case. The victim is represented by the central yellow squared box, relations by lines and suspects by coloured boxes. Each suspect is represented by a certain colour.

In Diagram B the complexity of diagram A is reduced in a simpler diagram with the three main suspects Said, Preben and Ole. The group has also included data from the technical investigations they have made such as analysing footprints, and depending on which theory they support they are placed under the three different suspects profile.

In this example one of the girls describe the process to the researcher:

Researcher: But how is that diagram (diagram B) different from this diagram (diagram A)?

Girl: (Pointing to diagram B) this is just an investigation of whose footprints it is and other examinations we have made, and this one (pointing to diagram A) is a poster so we more easily can work out who it is. So we can get an overview over who we think it is. This one (pointing to diagram B) is more an investigation of some of the things we have done and this (pointing to diagram A) is a quick overview of all the people in the case.

The girl describes how the second diagram is a representation of the knowledge the group have at the late stage of the inquiry after the various investigations and examinations of technical tests. Their investigations have resulted in a more specific suspicion against two of the suspects in the case. This example shows how the pupils within the learning space of the game setting can handle the relatively complex data they are confronted with.

Community learning in the game

The groups have different cases and are therefore not competing directly with the other groups. There is a general competition in solving the case, but as the groups have different cases there is no reason to withhold information from the other teams. Some characters appear in several cases and the groups can therefore assist each other by passing information on to the other groups. The following is an example of two of the groups (groups 1 and 2) discussing methods and results. A boy from group 2 is sitting at a table, busy making a poster to present the group's work at the upcoming meeting. A girl from group 2 stands beside him and show him her group's diagram.

Girl: (Turns away to get the groups diagram) you have to see ours. It's really exciting. She was shot with a hunting rifle. And then we thought…

Boy: (Points to the victim's name at the diagram) who shot her?

Girl: She was shot with a rifle.

Boy: Hmmm

Girl: Why?

Boy: Then it's probably someone that is a member of a hunting club

Girl: Yes, because this guy there he sometimes go hunting (pointing to one of the suspect's name, Poul Berg, in the diagram). Do you have anything on Poul Berg?

Boy: No

Girl: Do you have something on this guy (pointing at another name at the diagram).

Boy: He is the one that was killed in our case.

The girl reports goes back and reports to her group what the boy has told her. This is an example of how diagrams are used for exchanging ideas and methods within the social context in the game-based learning environment. How the game design can be a frame for this social learning will be further discussed in the following.

DISCUSSION

In this paper, I have presented the game Homicide and the first play tests of the game. In these first tests of the game, the community learning in the game-based learning environment has proven highly interesting. In the observations of the play-test, we not only observed the pupils handle large amounts of data to establish theories in the game-based learning situation: They also independently re-designed the game tools in an effort to establish a coherent hypothesis. These tools became increasingly more sophisticated during the week-long play-test, which indicates that the pupils not only used individual skills, but that they operated on a methodological meta-level where tools and methods are evaluated and adjusted to meet the challenges of the game. Initially only one group designed diagrams, but the other examples from the class interaction shows that the other groups not only learned this method from the first group, they went on to re-engineer these designs.

In solving the game tasks, the pupils work together in and outside groups and, as we have seen in the examples, ideas and methods disseminate among groups in the class. This happens in formal settings, as in the example with the meeting where a boy presented his case using a diagram, but also in more informal settings as in the example with the two children that discussed their different cases. This exchange and sharing of knowledge is not in any way surprising, but is in fact typical for children and young people's learning praxis, especially in informal learning settings which has been mentioned as an important factor in children's learning from digital media (Jessen 2001, Sørensen & Olesen 2000, Steinkuehler, 2004). It is relevant take a closer look at the means that support this, as it is an important learning factor not just in relation to learning scientific subject matter, but also in terms of pupils developing their competences to actively participate in project-based learning and learning networks that in many ways differ from the formal educational system they meet at school.

These examples indicate that this IT-supported role-playing game supports the building of communities and communities of practice (Wenger, 1998). It is interesting to identify the game design elements that are likely to support these social processes. Game factors such as non-competitive elements facilitate groups helping each other instead of competing against each other. Another important design factor may be that the computer works more as an active assistant and database than as a gaming space. Most of the learning and gaming action takes place away from the computer, around tables with printed case files or in a laboratory. How this

enhances or limits social interaction and what the result would be of moving this physical interaction to an online setting will be the subject for future experimentation and discussion.

The game operates with roles of the learner and different communities of practice on different levels: First, there is the community of practice in the class-room consisting of students and teachers. On another level we have the simulated science practice where students perform a scientific process of inquiry using the same tools as real-life experts, although in a fictional setting of course. We have seen no indications that pupils play specific characters, so our assumption is that in a simulation of a real life science practice, learners interact directly from the perspective of the real-life expert rather as a real-life expert. The nature of these different communities and how they interact calls fro more research though.

Another important factor in the discussion of means that support community learning is the teacher's participation in the game. This will be the subject of future studies and experimentation, so I shall not go into a long description of this element here, just briefly describe some of our observations. We became aware of the different roles teachers play in the game fiction. In the game manual, they are advised to try to play the role of the chief of investigation and try to simulate an 'authentic' police investigation. They are advised to encourage the pupils to run the process independently and not try to control it. They are advised to play the role of the chief in the meetings that form part of the game, and to ask questions like: 'What is your theory and why?', 'What proofs have you got?' and 'What do these investigations prove?'. Some teachers easily take on this role in the simulated practice and constantly refer to the professionalism that is expected from the students. Other teachers stay in the classic teacher role and refer to the game as a set of exercises. What importance this has for the simulated learning practice is a subject for further investigation and experimentation.

We also need a deeper understanding of what and how the children learn in these game-based learning environments and whether this knowledge – e.g. knowledge about the process of inquiry - can be transferred to other educational settings as a general approach to scientific problems. We know little about this game-based learning space, about why the design is effective and if and how it may be adapted to other settings. The observations presented here raise several questions that might serve as subject for future studies; what communities are formed in these environments and what roles do the players play? How do communities of practice in the classroom relate to communities of practice in the simulated science practice in the fiction? What roles do students take on in the simulation of science practice? We need a deeper understanding of social learning dynamics in game-based simulated situated science learning spaces and of how we integrate the social context in schools' science education in the game design.

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