TAXONOMIC CONCEPTS FOR STORYBOARDING DIGITAL GAMES FOR LEARNING IN CONTEXT

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Abstract: The design and employment of digital games for serious purposes such as learning has several prerequisites. Designing a game that affects human players effectively requires the anticipation of particular human game playing experiences. Recent digital games taxonomies provide the WHAT and storyboarding is the technology for determining the HOW of planning the manifold of potential affective experiences in digital game playing. Game-based learning needs storyboarding and storyboarding needs concepts of digital games taxonomies. The appropriate consolidation of taxonomies and storyboarding results in explicit media didactics in context.

1 THE AUTHORS' POSITION

This paper aims at advocating the authors' position on inevitable preliminaries of game-based learning:

- P1 Game-based learning bears promising potentials due to the attractiveness of game playing to young learners and because of the extra motivation it is bringing with it.
- P2 Playing serious games may affect human learners by what they experience when playing the game.
- P3 Serious games do not work per se, but require elaborate contexts of employment for learning.
- P4 Storyboarding is the anticipation and organization of human experience.
- P5 Digital games taxonomies explicate peculiarities of game playing relevant to affective experiences.
- P6 Appropriate taxonomic concepts specify contexts in which playful learning experiences may affect human learners effectively.

Particular emphasis is put on the propagation of

- C1 concepts of storyboarding in serious game design,
- C2 concepts of games and game playing taxonomies.

Besides the systematic theoretical development, the authors' position is illustrated by means of some real-life case study. The case study itself is based on a certain original game concept, its implementation, and its qualitative evaluation. These preliminaries are published in the first author's conference publications (Jantke, 2006b) and (Jantke, 2010b).

2 MOTIVATION

In contrast to earlier critical assessments such as, e.g., (Jantke, 2006a), (Seelhammer and Niegemann, 2009), and others, the authors feel encouraged by recent reports on successful serious games projects from (Chaffin and Barnes, 2010), (Cooper et al., 2010) and (Thomas and DeRosier, 2010) to (Jenson et al., 2011).

Besides mastery of the domain topics, the design, the implementation, and the employment of digital games for serious purposes have numerous prerequisites. Designers and developers need to anticipate the particular human activities expected to affect the players effectively. Storyboarding[1] is the anticipation of human experience (Jantke and Knauf, 2005).

Comprehensive work like (Fullerton et al., 2004) reflects iterative approaches to find ways of provoking effective human players' activities. Having game based learning in mind, this work illuminates the need to anticipate more than just playing a certain game.

Metastudies such as (Dondlinger, 2007) reveal that the necessary prerequisites of playing which may have an intended desirable impact are still extremely vague and cover elements such as "narrative context, rules, goals, rewards, multisensory cues, and interactivity" (ibid., p. 28). From insights of such a generality one can hardly derive any game design decision.

The authors want to be considerably more precise.

[1]It is a frequent misconception to see storyboarding as the organization of learning materials such as PDF sources.

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3 BACKGROUND

This paper is based on two widely independent areas of research: storyboarding for e-learning (Jantke and Knauf, 2005) and games taxonomies (Jantke, 2010c). For reasons of space, this introduction is kept short. The following three sections from 4 to 5, in particular, are dedicated to some consolidation of storyboarding and taxonomies. Section 6 is surveying the case study.

3.1 Storyboarding for e-Learning

Design and development of digital systems intended to support human learning processes need some careful a priori specification. What the authors are aiming at is much more than just system specification as known from conventional software engineering. The processes of human learning are rather involved and need a certain firm scientific foundation. Besides educational psychology, in general, and particular aspects like motivation (from (Malone, 1981) to (Hoffman and Nadelson, 2010; Paas et al., 2005)), mental effort (from (Salomon, 1983) to (Paas et al., 2005)), and cognitive load (from (Sweller, 1988) to (Kalyuga, 2009; Mayer and Moreno, 2003), there are many lessons learned from recent applications like (Callaghan et al., 2010; Chaffin and Barnes, 2010; Cooper et al., 2010; De Castell et al., 2007; Hawlitschek, 2009; Jenson et al., 2011; Shelton and Scoresby, 2011; Thomas and DeRosier, 2010).

From the two present authors' constructivist point of view[2], learning needs the learner's activity. And effective learning is usually best supported by affective learning experiences. Storyboarding is the organization of experience ((Jantke and Knauf, 2005), p. 25).

For the operationalization of this educational perspective, the authors have introduced storyboards as hierarchically structured graphs. Composite nodes of such a graph may be substituted by other graphs determining the concerning human activity in more detail. They are named episodes. Atomic nodes, in contrast, are named scenes representing elementary learner activities or services of the IT system.

For illustration, an atomic node may describe just a media file (text, picture, animation, audio, video) presenting learning content, an exercise, a particular communication event (talking to a co-learner, asking somebody for information, . . .) or any off-line action.

[2]An in-depth discussion of positions of constructivism, unfortunately, is quite far beyond the limits of the present paper. Interested readers are directed to sources such as, e.g., the collection of chapters edited by Sigmund Tobias and Thomas M. Duffy entitled *Constructivist Instruction: Success or Failure?*, by Routledge, 2009.

3.2 Digital Games Taxonomies

Digital games taxonomies provide conceptualizations for systematizing the extremely heterogeneous and dynamic field in which innovative ideas and those that appear innovative, at least, come and go frequently.

Some approaches like the one called the Ilmenau Taxonomy (Jantke, 2010c) are canonical and apply to every digital game. Refinements such as the so-called Erfurt Taxonomy (Jantke, 2010c) introduce particular concepts (Jantke, 2010a) which apply only in some conditions. Furthermore, there are highly interesting specialized taxonomies focusing only a few specific phenomena such as (Lewis et al., 2010), e.g., in which the authors systematize video game bugs.

Taxonomies, in general, are frequently seen as multi-dimensional spaces in which every object of interest–in the present investigation always a game–can be characterized by its values according to the dimensions of the space. In the most simple case, a game is characterized by a point in the space. But in contrast to conventional mathematics, dimensions can not be assumed to be orthogonal. Consequently, certain games are better imagined as clouds sitting somewhere in the space. The mutual interdependence of taxonomic dimensions is discussed in some detail elsewhere (Jantke, 2010a; Jantke, 2010c).

Let us investigate a few taxonomic dimensions in more detail. To every digital game, it applies that

- the game is a computer program,
- the game is entertainment media,
- in computer science and in entertainment media, there is nothing more interactive than games.

Consequently, there are 3 canonical dimension along which every digital game G may be described in some reasonable detail. What are the characteristics of G seen as a computer program? What are the characteristics of G seen as entertainment media like, e.g., film? What characterizes human behavior when playing the game? In other words, what does a human being experience when playing G? To answer these three questions is, indeed, canonical (Jantke, 2010c).

The idea of the Erfurt Taxonomy (Jantke, 2010c) is to systematize–beyond the canonical dimensions of the Ilmenau Taxonomy–all the aspects that may be relevant to the one digital game, but completely irrelevant to another one.

For illustration, music is playing a crucial role in several interesting digital games. In contrast, there are numerous other digital games that need no sound at all. Therefore, 'the role of music' or, simply, 'music' is a typical dimension of digital games taxonomies beyond the canonical minimum.

The variety of taxonomic dimensions for games is overwhelmingly rich. Among others, there is the dimension of ‘contemporary politics’, the dimension of ‘erotics’, and the dimension of ‘humor’. Readers may immediately imagine several refinements.

Other interesting dimensions refer to issues of gender, of language, of culture, and so on. Many of them are rather involved. For illustration, think of references from a particular digital game to other media products and pieces of art such as literature, motion picture, and the fine arts. To a certain audience, these references are a source of enjoyment and satisfaction, whereas they miss some other audience completely.

Here is an illustration. The cartoon point & click adventure CLEVER & SMART is rather humorous and full of references. When playing this game, you control alternatingly one of two secret service agents. The agents’ boss in the games’ virtual secret service hierarchy is named “L”. Don’t you immediately think of Judi Dench starring as “M” . . . ?

The ‘role of time’ is a another particularly interesting dimension which should be divided into a larger number of suitable sub-dimensions. Prominent games in which mutually varying time phenomena play a crucial role are, e.g., BRAID, PRINCE OF PERSIA: SANDS OF TIME, and the point & click adventure SHADOW OF DESTINY.

The discussion of time leads to questions of the evolution of a game story, an interesting issue which, unfortunately, is beyond the limits of this paper.

Callaghan et al. describe a game-based learning approach in which activities beyond the limits of the virtual world are essential (Callaghan et al., 2010). The present authors call those taxonomic concepts ‘extra game play’ and ‘meta game play’, as sketched in (Jantke, 2010c) and (Jantke and Gaudl, 2010).

Digital games are bringing with them properties with respect to taxonomic dimensions. Vice versa, digital games may be classified by means of taxonomic concepts. For illustration, there are games that require a certain physical activity of the player which goes beyond the limits of controlling game playing via standard interfaces such as keyboards, game controllers, joystick, and steering wheels. Games of this sort are nowadays usually called exergames. Exergames as studied in (Lucht and Gundermann, 2009), (Park et al., 2010), (Sinclair et al., 2010), (Yang et al., 2010a), and (Yang et al., 2010b) have peculiarities which lead to a variety of further taxonomic concepts. Though those concepts are surely of interest in storyboarding and of a particular interest from a didactic point of view taking aspects of health care, e.g., into account, these issues are also beyond the limits of the present short conference contribution.

4 DIDACTICS AND STORYBOARDING

As briefly mentioned above, constructivism–according to the present authors’ understanding, at least–leads to emphasis on the learners’ experiences. Jenson et al. (Jenson et al., 2011), for instance, are “shifting the focus [. . .] from ′figuring out what people know′” to investigating questions “more like, ′what did you experience′” (ibid., p. 30).

Here, the authors’ storyboarding approach comes into play. When designing a digital game for certain learning purposes, it seems highly desirable to explicate the intended playing experiences of the human learner. When should she laugh? When and why should she be surprised? When and how to scare the learner? In which conditions should some learner face a certain conflict situation? And how to find a way out? There are infinitely many potential experiences to be set up with some educational purpose in mind.

Some experiences go beyond the limits of game playing itself. When, why and how should a learner interrupt game playing for initiating a certain conversation with other co-learners? When, why and how should a learner lean back and take time to contemplate the game playing experience so far? Should learners be encouraged to play repeatedly and should those cycles of repeated game playing be dovetailed with other experiences?

The answers to those and other similar questions need some representation within game development. According to (Jantke and Knauf, 2005), representations of anticipated experiences may be effectively written down as paths through storyboards.

In this vein, some didactic ideas and principles are getting different graphical representations on varying levels of granularity. Didactics becomes visible.

For illustration, imagine that studying a certain content needs a number of repeated exercises. Thus, suitable graphical representations, accordingly, might show certain cycles. There may be a main cycle, but there might also be several cycles distributed over the whole game playing experience.

As another illustration, imagine a field of studies in which collaborative learning is assumed to be highly advisable. Learners should talk to each other. A related storyboard for a serious game in this field has to embed game playing into human conversation. Storyboarding is no longer only storyboarding of the game itself, but specifies game playing within a more comprehensive context of learner activities.

Modeling didactic knowledge by storyboarding may go even further (Knauf et al., 2010) and take more complicated curricular processes into account–

another exciting issue beyond the limits of this paper.

5 FROM DIGITAL MEDIA DIDACTICS TO TAXONOMIES AND STORYBOARDS

One may take any of the numerous taxonomic concepts for pondering its usefulness for didactic design. For illustration, think of manipulations of time for the purpose of realizing repeated exercises of a certain type. Even the taxonomic concept of ‘bullet time’ known from shooter games[3] might be especially exploited for the set-up of training situations. Bullet time may help some users who have difficulties with a certain task to try it again under simplified conditions.

The way of presenting content clearly affects the way of perception (Mayer, 2002), so what about ways beyond play in game-based learning

Managing cognitive load has to be taken seriously (Kalyuga, 2009). Load problems are surely relevant to game-based learning (Mayer and Moreno, 2003), but rarely mentioned explicitly, as playful learning seems so overwhelmingly promising. Assessment of cognitive load, as one might expect, is known to be involved (Brünken et al., 2003), even if digital games are still out of scope. Certain earlier work such as (Leacock and Nesbit, 2007) does not seem to apply.

To sum up very briefly, it is not sufficient simply to provide a particular game for game-based learning.

Every digital game is bringing with it a certain game-specific load, because players have to master the game mechanics and need to focus both overall goals and current quests.

There is abundant evidence for the need to specify context conditions in which intended learning effects are likely to occur.

Certain concepts of digital games taxonomies are helpful for the a priori specification of game playing experiences. There are, in particular, several concepts describing phenomena beyond the limits of a single game playing session (Jantke, 2010a). For the sake of illustration within the present paper, the authors focus on ‘extra game play’ and ‘meta game play’.

The taxonomic dimension of ‘extra game play’ subsumes all phenomena of intentionally interrupting game play for getting engaged in certain extra-game activities such as communication, e.g.

[3]Bullet time means the feature that allows for playing an action–in particular the player’s shooting of an adversary–in slow motion. Besides the clear advantage to shooting in real time, bullet time is appreciated as a feature that allows for enjoyment of graphically attractive actions such as jumping and shooting at the same time.

The taxonomic dimension of ‘meta game play’ subsumes all phenomena on a meta-level w.r.t. single game play sessions such as, e.g., comparing effects in dependence on certain game parameter settings.

6 A STORYBOARDING CASE STUDY BASED ON TAXONOMIC CONCEPTS

Reflective thinking is playing a rather prominent role in technology-enhanced learning (Hong and Choi, 2011). This section is presenting the present authors’ case study in game-based learning in which a certain type of the learner’s reflective thinking is decisive. Taxonomic concepts and their particular appearance in storyboarding encode, so to speak, the authors’ actual didactic approach. Didactics becomes visible.

6.1 From Jostle to Gorge

There is a particularly simple game named JOSTLE (Jantke, 2006b)[4] for between one and four players. Some of them or even all may be computer programs; the latter makes sense in case a player wants to inspect the mutual interaction of Artificial Intelligence (AI) strategies. JOSTLE is a simple turn-based path game. Every player regardless of whether being human or AI is controlling some team of robots. These robots are heading for some target area where they can score points according to some simple rule. On their way, the robots are jostling each other.

The game has been developed as a research tool to allow for the comparison of different strategies–human or AI.

AI strategies can be tuned by the human player; this makes particular sense if the player is a learner dealing with particular questions and phenomena of Artificial Intelligence.

At this point, it becomes understandable that even the extreme case of setting up 4 computer programs of different character like, e.g., the good, the bad and the ugly (Gaudl et al., 2009) and let them play with and against each other makes sense. Human learners may study AI by tuning AI agents, watching them, re-tuning them, continue watching them, and so on.

But the players’ number of choices in JOSTLE is quite limited. There are not many opportunities to reveal an AI agent’s character. For this reason, the concepts of JOSTLE have been enriched toward a more flexible game named GORGE (Jantke, 2010b).

[4]This paper has been winning a best paper award on the CSIT 2006 conference in Amman, Jordan.

The crucial new feature of GORGE are gorges, i.e., interrupts of the paths. Crossing the gorges needs a specific form of collaboration of at least two different robots (see (Jantke, 2010b) for more details). This gives rise to a variety of agents' behaviors such that players regardless of being human or AI may reveal some character, so to speak, ranging from a helper or a wimp to a freeloader or a quarreler.

6.2 Learning Goals and Didactics

GORGE is, very much like JOSTLE, more a research tool than a game. However, the game is sufficiently interesting to be played several times.

The educational potential of the game lies in the opportunity to easily control the characteristics of programmed players and, subsequently, to investigate the effects of varying settings.

Figure 1: Setting up some programmed AI behavior.

Humans can set up the programmed adversaries' preferences according to four dimensions: the desire for jostling others (left upper parameter in figure 1), the willingness to cooperate for crossing any gorge (left lower parameter), the willingness to step down into a gorge by himself (right upper parameter), and the engagement for salvaging others from a gorge (right lower parameter). This allows for a surprisingly large number of perceivably different "AI characters".

Based on the potentials of the, so to speak, serious game GORGE, some learning goals are set:

- G1 Learners shall understand how setting parameters results in system behaviors that appear somehow intelligent or human-like.
- G2 Learners shall appreciate the importance of AI to an interesting and flexibly varying experience of digital game playing.
- G3 Learners shall enjoy the power of being in control of AI and shall develop some confidence in being able to control computer technology.

To achieve the goals above, the authors rely on exploratory learning which is largely self-directed, which involves a high degree of learner activity, and which is essentially playful and really a lot of fun. Reflective thinking is inevitable for general insights.

These are the authors' key didactic principles to be implemented by means of taxonomic concepts in storyboards–didactics will show in the design below.

6.3 Didactics and Taxonomic Concepts

Studies suitable to achieve goal G1 surely need some investigation of several varying settings of the NPCs[5] preferences. It is highly unlikely that unexperienced players find immediately two sufficiently interesting and sufficiently different settings of NPC parameters. There is some need for employment of the taxonomic concept of extra game play–players should be allowed to leave some current game play for modifying the settings on the fly. Successfully tuning parameters during game playing may contribute to achieving G3 as well.

Figure 2 shows some typical situation in which a human player might wish to interrupt the game for changing settings. His robots on the upper path on the right are about to win the game without much of the NPCs' resistance who currently waste their energy in restless jostling on the other path.

Figure 2: Game playing scenery giving rise for an interrupt.

Goals G2 and/or G3 may be achieved if a human player has opportunities of experiencing human-like or, at least, believable NPC behavior. But behavior as a whole does only unfold throughout complete game play. For a substantial comparison of varying NPC characters, one needs to play several times–an issue of the taxonomic concept of meta game play.

[5] NPC is short for non-player character in a digital game.

Is it really true that playing GORGE is only fun if at least one of the (NPC) adversaries plays somehow aggressively? You can hardly tell from playing only once. Suppose you have equipped some NPC with an aggressive behavior by, say, setting the preference of jostling to a maximum and, in addition, setting the preference of collaboration to a minimum. It might possibly happen within a certain game play that, by chance, there are not sufficiently many opportunities for the evil to show. Hence, one should play again.

6.4 Taxonomy-based Storyboarding

Storyboarding of game-based learning means more than storyboarding the game play as can be seen in figure 3. In particular, the two feedback arrows represent taxonomic concepts such as extra game play (the inner loop) and meta game play (the outer loop).

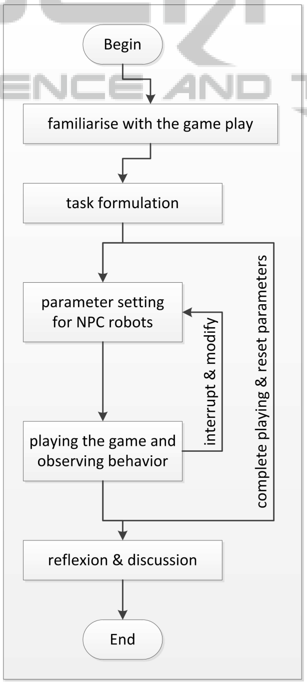

Figure 3: Top level storyboard of playful learning with GORGE within a context of reflecting playing experience.

Recall that every node (rectangular box) is an episode which may be expanded by some graph substitution to specify details of the anticipated e-learning process. The figure 4 shows part of a larger graph refining the "playing the game . . . " episode of figure 3 above.

After observing robots getting stuck in intensive jostling, there are foreseen three variants of learner behavior. The role of storyboarding is to explicate several needs such as, for instance, opportunities for players' communication about observed phenomena.

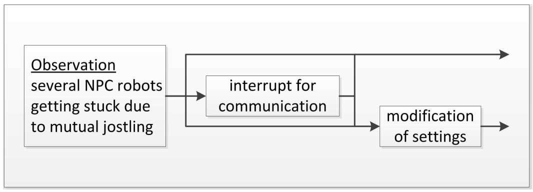

Figure 4: Cutout from some episode expansion.

6.5 Evaluation of Game-playing Impact

The authors have undertaken several qualitative and quantitative evaluations of the didactic design sketched in the section 6.4 before (left column of this page). Setting up evaluation experiments, performing evaluations, processing the data, and finally publishing the results is a field of scientific work in its own right clearly going beyond the limits of the present position paper. Nevertheless, the authors would like to inform the audience about a few typical evaluation activities and about a few characteristic results.

Game playing experiences as anticipated and specified by means of storyboarding as in section 6.4 have been taking place on several exhibitions and fairs based on different implementations of the game GORGE ranging from stand-alone executables through a Silverlight browser game implementation to some touchscreen version based on Unity.

There have been young players of an age ranging from 10 to 20 years and adults including groups of teachers from different school types. Subjects playing the game in an evaluation session have been playing individually or came in groups of varying size. There have been groups of students and groups of teachers as well.

To sum up briefly, the experimental settings lead to results demonstrating that the game-based learning didactics implemented according to the storyboards sketched in section 6.4 achieve the goals G1, G2, and G3, in general.

Furthermore, there is some variety of additional insights. Identical experiments in two different larger cities with groups of students of an age between 13 and 20 years provided almost identical results like the following one.

First of all, the subjects have been introduced to the game and its peculiarities. Next, they have been asked to set up three NPC characters such that–according to their own (unspecified) expectations–other students of their age would most likely consider the experience of playing GORGE as entertaining as possible. Interestingly, all the subjects–without any single exception–have been setting up one of the NPC characters to be highly aggressive. In a subsequent qualitative analysis, they explained unisono that some degree of the in-game adversaries' strength including aggression is considered inevitable to make a game challenging and, thus, enjoyable.

Another interesting result of these two particular experiments is that all subjects have chosen settings between the extreme values for at least one of the other NPCs. The reason is a desire for NPCs not so easy to see through–players have high ambitions.

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CLOSING REMARK

By their very nature, storyboards are usually a bit larger than the cutouts shown on the preceding pages. Therefore, the authors decided to offer a few slightly larger examples in an appendix below.

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APPENDIX

The following figures show a few more storyboards from the case study discussed in section 6 of the contribution.

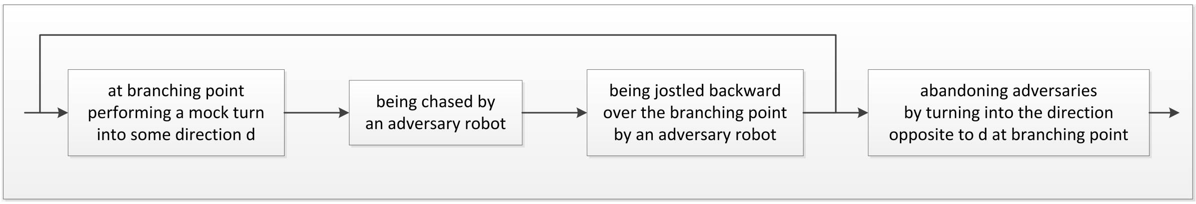

Figure 5: Storyboard of some potential experience of fooling the player's adversaries by luring robots into the wrong direction; a game playing experience relevant to the learning goals G2 and G3, in particular, enjoyed for feeling the player's superiority.

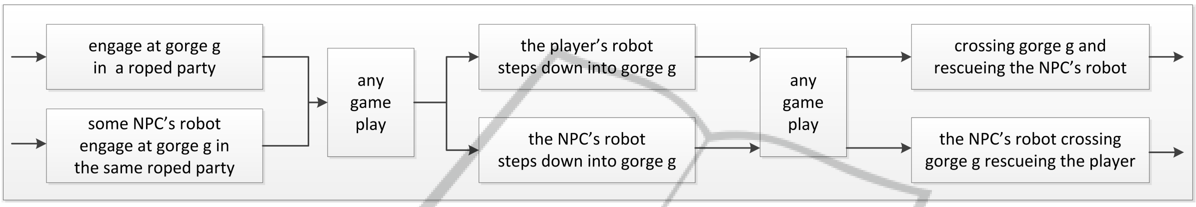

Figure 6: Storyboard of cooperation with some NPC at some gorge for forming a roped party and crossing the gorge together; a game playing experience relevant to learning goal G2 and, furthermore, providing a good basis for the discussion of strategies.

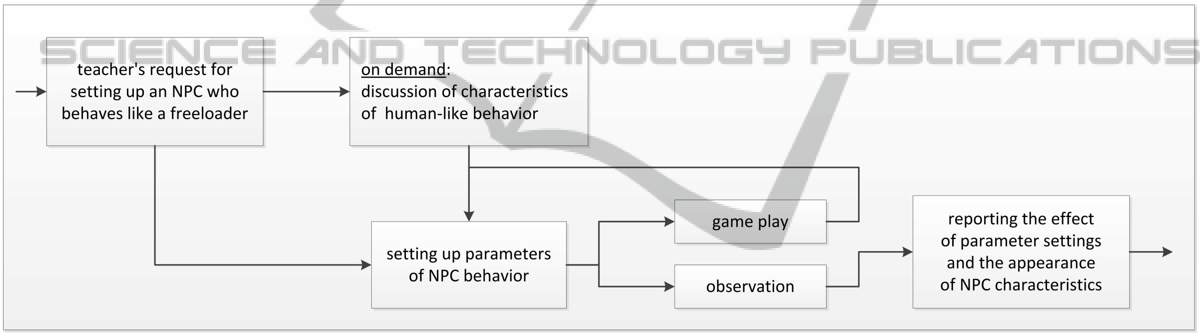

Figure 7: Storyboard of a learning activity in which a learner is asked to simulate a certaion human-like playing behavior; the first scene specifies a teacher activity whereas the next scene on the right specifies some human communication, perhaps, among several learners or in some student-teacher dialogue; the branching between 'game play' and 'observation' mean simultaneous actions (in contrast to all the other branching points on display here which specify alternative player activities).