Methods and Technologies for Wrapping *Educational Theory into Serious Games*

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Abstract: Although play does undoubtedly take a significant place in the development of human individuals and animals allowing for a manifold of risk-free exploration and experiment, contemporary serious games largely fail in meeting the high expectations of game-based learning. Educators know how to teach. Moreover, they know how to set up conditions, including approaches to playful education, in which learners can actively engage. In particular, experienced educators know how to adapt to a particular learner's needs, wishes and desires. But digital games including those named serious are computer programs. They do not know about didactics. There is a need for methods and technologies suitable to bring educational principles and pedagogical patterns into digital systems intended to enhance learning. The authors advocate the method of *storyboarding* and the technology of *storyboard interpretation* to wrap educational theory into e-learning systems, in general, and into serious games, in particular. Some comprehensive case study demonstrates the feasibility of this approach.

1 THE AUTHORS' POSITION

Edutainment started as a serious attempt to create computer games that taught children different subjects. Arguably, it ended up as a caricature of computer games and a reactionary use of learning theory.

[(Egenfeldt-Nielsen, 2007), p. 42]

Egenfeldt-Nielsen's critical view at serious games[1] is supported by a variety of critical studies such as, e.g., (Jantke, 2006) and (Jantke, 2007).

Apparently, the crux is "to get educational theory into serious games". This key issue is not particular to serious games, but applies to educational media, in general.

Latterly, some authors discuss the relevance of a few educational approaches to game-based learning (see, e.g., (Jin and Low, 2011), (Kirkley et al., 2011), (Leemkuil and de Jong, 2011)). Kirkley and his co-authors, for instance, investigate the way of getting a five-stage learning cycle[2] of problem-based learning perspectives (Duffy et al., 2009) realized in a certain serious game. The game play is discussed in much detail, but it remains largely open *how* to bring the educational theory into the digital system.

The present contribution is aimed at advocating the authors' following position.

> *Storyboarding is a methodology appropriate for anticipating user experiences of media interaction including game play and learning. Consequently, storyboarding is a methodology of didactic design.*

In accordance with (Jantke and Knauf, 2005), the authors exclusively consider digital storyboards. Digital storyboards may be easily manipulated by computer programs for purposes such as checking completeness and consistency, for instance.

Digital storyboards allow for going even further as expressed by the authors' supplementary position to be advocated by the present paper.

> *Storyboards may be interpreted algorithmically. Systems of e-learning, in general, and serious games, in particular, may run digital storyboards according to the educators' specification.*

The recent *storyboard interpretation technology* (see (Fujima et al., 2013) and (Arnold et al., 2013)) allows for experimenting with variants of educational principles and pedagogical patterns.

[1] See (Sawyer and Smith, 2008) for debating the concept.

[2] The topical literature is full of learning cycles ranging from John Dewey (Dewey, 1938) to David Kolb's Learning Style Inventory (Kolb, 1984) to ad hoc cycles in domains such as nursing education (Murphy et al., 2011).

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2 BACKGROUND THEORY

Educational perspectives and theories are manifold. This position paper cannot afford any reasonable overview. Instead, the authors confine themselves to their application domain of critical thinking (Bassham, 2008; Fisher, 2006; Garz et al., 1999).

There is the crucial question of how to wrap, so to speak, the educational theory of critical thinking and moral reasoning into some serious digital game.

2.1 Kohlberg's Psychology of Moral Development

Kohlberg's substantial theory of moral development (Kohlberg, 1984) which was inspired by Piaget's approach (Piaget, 1932) is discussed as an example of a theory that views conscious moral reasoning as a central component of morality. Kohlberg's method to study the strength of moral judgment was quite simple. He used Piaget's story-telling technique to tell people stories involving moral dilemmas. He presented mainly children and adolescents dilemmas in which different moral factors conflicted. In each case was a choice to be considered, for example between the rights of some authority and the needs of some deserving individual who is being unfairly treated.

The most famous one is the Heinz dilemma: *A woman was near death from a special kind of cancer. There was one drug that the doctors thought might save her. It was a form of radium that a druggist in the same town had recently discovered. The drug was expensive to make, but the druggist was charging ten times what the drug cost him to produce. He paid $ 200 for the radium and charged $ 2,000 for a small dose of the drug. The sick woman's husband, Heinz, went to everyone he knew to borrow the money, but he could only get together about $ 1,000, which is half of what it cost. He told the druggist that his wife was dying and asked him to sell it cheaper or let him pay later. But the druggist said, "No, I discovered the drug and I'm going to make money from it." So Heinz got desperate and broke into the man's store to steal the drug for his wife.*

Kohlberg asked then a series of question, e.g.:

- Should Heinz have broken into the laboratory to steal the drug for his wife? Why or why not?
- Would it change anything if Heinz did not love his wife?

Kohlberg found that children from many cultures typically move through a sequence of levels and substages, although not everyone reaches a higher level of moral reasoning.

2.2 The Social Intuitionist Model (SIM) & Moral Foundation Theory (MFT)

The Social Intuitionist Model of moral judgment (Haidt, 2001) is a valuable contrast to the rationalist approach of Kohlberg, where moral reasoning is described as conscious deliberation. Haidt, instead, posits that moral judgment is mostly based on automatic processes–moral intuitions–rather than on conscious reasoning. People engage in reasoning primarily to find evidence to support their initial intuitions. Accordingly, the SIM is seen as prequel to the MFT.

Where does morality come from? Why does morality vary so much across cultures? Is morality one thing, or many?

In brief, the MFT proposes that six (or more) innate and universally availabale psychological systems are the foundations of intuitive ethics (Graham et al., 2011), (Graham et al., 2013)). These so-called moral foundations are characterized by unique conforming challenges, contents, triggering stimuli, virtues, and emotions. In Western cultures issues with Harm/Care and with Fairness/Cheating dominate. The moral foundation Harm/Care is triggered by suffering and distress, especially expressed by one's own kin. It's accompanied by the emotion of compassion. The Fairness/Cheating foundation deals with equality, cooperation, and deception. It's accompanied by the emotions anger, guilt and gratitude. Further moral foundations are: Loyalty/Betrayal domains regulate group cooperation through pride and anger. It underlies virtues of patriotism and self-sacrifice for the group. Whereas Authority/Subversion domains control hierarchies by recruiting the emotions respect and fear. It underlies virtues of leadership and followership. The Sanctity/Degradation domain is referring to food, health, and sexuality (thus conceiving the body as sacred). This foundation is mostly accompanied by feelings of disgust. The latest moral foundation is the Liberty/Oppression domain and deals with feelings of reactance and resentment of people toward those who dominate them and restrict their liberty.

2.3 Argument Mapping

In general, argument mapping (van Gelder, 2013) (see also (Twardy, 2004)) is described by means of diagrams which show the structure of an argument or of a set of arguments. Normally these are box-and-arrow diagrams (graphs in terms of mathematics, see section 4.4). Argument mapping is akin to other mapping procedures such as mind mapping and concept mapping, but it focuses on the logical, evidential or inferential relationships among propositions.

3 WRAPPING TECHNOLOGY

Quite intuitively and largely informally speaking, assume you adopt psychological and/or pedagogical positions to be implemented within some technology-enhanced educational framework such as a serious game. How do you make sure that your theory really works, i.e. it shapes the human-system interaction? In other words, how do you wrap, so to speak, the educational theory in e-learning systems, in general, and in serious games, in particular?

The authors' ultimate answer is *Storyboarding* à la (Jantke and Knauf, 2005).

3.1 Storyboarding Human Experience

Storyboarding means the organization of experience (Jantke and Knauf, 2005). To allow for an effective computational usage of storyboards throughout the process of design and implementation (see, e.g., section 3.4), storyboards are assumed to be digital. Conceptually, storyboards are finite, hierarchically structured, indexed families of finite, directed graphs.

Seen as a family of graphs, every storyboard is of the form $\mathcal{F} = \{\mathcal{G}_i\}_{i \in I}$, where I is any finite index set. For simplicity, one may assume $I = \{1, \ldots, k\}$, where k is any natural number indicating how many graphs belong to $\mathcal{F}$. Every individual graph $\mathcal{G}_i$ is of the form $[N_i, E_i, sub_i, c_i]$, where, as usual N_i and E_i denote the nodes and the edges of $\mathcal{G}_i$, respectively. The mapping $sub_i : N_i \rightarrow 2^I$ is assigning to every node a set of indices telling which graphs of the collection may be substituted for this particular node. Further, the mapping c_i assigns to every edge some condition of executability[3].

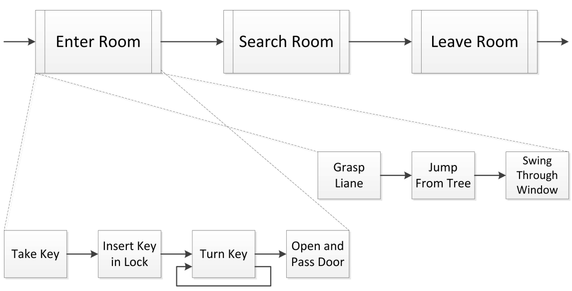

Figure 1: Illustration of Alternative Graph Substitutions.

[3]Due to the lack of space, all details of logics and logical reasoning are suppressed throughout the present paper. Variants of logics in use are discussed, e.g., in (Jantke and Arnold, 1996). Note, furthermore, that the present approach is slightly different from (Arnold, 1996), where constraints are not assigned to edges, but to nodes. The approach underlying the present paper is more expressive.

For the purpose of the present position paper, it is sufficient to understand storyboards as collections of graphs as exemplified in figure 1. Those nodes which may be subject to graph substitution are called *episodes*. Other nodes are called *scenes*. Every scene has some meaning in the domain such as showing some picture or playing some video, presenting some exercise to users, running an animation, and the like.

3.2 Layered Language of Ludology

(Lenerz, 2009) discusses the description of media experiences on different levels of granularity–the so-called *Layered Languages of Ludology*. Similarly, educational theory has varying levels of abstraction.

Storyboarding is an appropriate technology of top-down design beginning on high levels of abstraction.

3.3 Pedagogical Patterns

To keep it short, it is sufficient to know that the authors take the origins such as (Alexander, 1979) as well as modern ad hoc approaches toward the needs of digital games research such as (Björk and Holopainen, 2004) and (Jantke, 2012) into account. The unprecedented strength and clarity of formal approaches such as (Angluin, 1980) is preferred due to the intention to work with patterns algorithmically (Jantke, 2009).

This allows for dealing with pedagogical patterns described largely informally in everyday language (as in (Pedagogical Patterns Advisory Board, 2012), e.g.) more stringently using the graph-based storyboarding approach as adopted in the present publication (see (Jantke, 2013) for a more comprehensive study).

Pedagogical patterns are–with respect to above-mentioned *Layered Languages of Ludology*–lower level concepts. Patterns of learner activity may be represented as "smaller" graphs for possibly multiple usage, i.e. for substitution in different places.

3.4 The Technology of Digital Storyboard Interpretation

The so-called *Storyboard Interpretation Technology* is a very recent technological innovation published for the first time in (Fujima et al., 2013) and (Arnold et al., 2013). The essence of this novel approach is to make digital storyboards immediately executable. E-learning systems and digital games work like interpreters–a term and an operational understanding adopted from computer science–running, so to speak, on the storyboard. In doing so, the system checks at every scene how to interact with the human learner.

4 THE GAME-BASED LEARNING CASE STUDY “CATCH 22”

This section is intended to demonstrate the authors’ positions by means of some practical application: the serious game “Catch 22”. Wrapping technologies introduced in the preceding section have been deployed for a certain implementation surveyed in the sequel. Educational theory is reflected by some storyboard structures anticipating intended player experiences.

4.1 Underlying Educational Theory

Kohlberg did not ascribe moral development and moral judgment to innate factors, but rather attributed the transition between levels (pre-conventional, conventional, post-conventional) as driven by the opportunities afforded in everyday social interactions. Alteration may occur as a result of everyday role taking and change of perspective fostering empathy, or it may be driven by reflections about moral situations. Dilemma-discussion suits perfectly to encourage critical thinking, perspective changes and moral reasoning skills.

Haidt’s SIM, in contrast, is understood as a social model in that it deemphasizes the private reasoning and emphasizes, instead, the importance of social and cultural influences. It states that moral judgment is a dual process, which is generally caused by quick moral intuitions, so-called automatic evaluations, and is followed (when needed) by slow, ex post facto moral reasoning, so-called effortful conscious mental activity.

According to (Haidt, 2001), the underlying SIM (see section 2.2) is visualized as in figure 2 below. The numbered links, drawn for Person A only, are

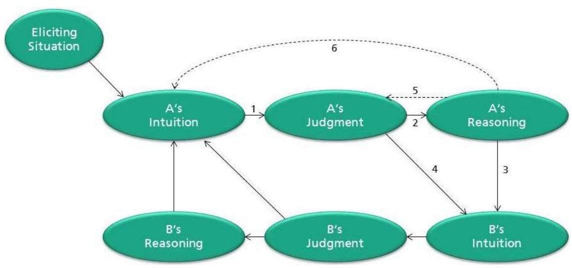

Figure 2: The Social Intuitionist Model of Moral Judgment.

(1) the intuitive judgment link, (2) the post hoc reasoning link, (3) the reasoned persuasion link, and (4) the social persuasion link. Two additional links are hypothesized to occur less frequently: (5) the reasoned judgment link and (6) the private reflection link.

4.2 Top-level Serious Game Design

We implemented Kohlberg’s dilemma-discussion approach combined with Haidt’s SIM in a digital game we called “Catch 22” to educate moral reasoning. For this purpose, we designed six dilemma-situations referencing the moral foundations mentioned in sec. 2.2.

The player wanders around in a 3D-world, has to solve quests and deals thereby with various virtual people who involve the player in moral dilemmas. The decision making process follows ad-hoc to the exposition and experience of the dilemma.

Target of the game is to enhance critical thinking skills and to raise awareness of the complexity of moral reasoning. For this purpose, the reasons and objections, which count for the chosen position, are structured and arranged in argument maps.

According to the authors’ position advocated by means of the present paper, emphasis is put on the question how to wrap, so to speak, Kohlberg’s and Haidt’s theory into the digital system to be developed. Didactic principles underlying an e-learning design and implementation become structurally visible.

4.3 Wrapping Educational Theory Top-down

To wrap educational theory in a serious game like “Catch 22”, it was necessary to grapple with game design.

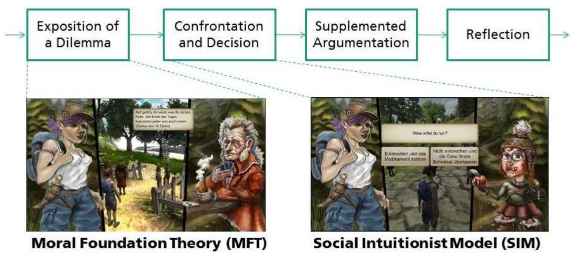

Figure 3: Some Excerpt from a High Level Storyboard of “Catch 22 ” Experience of Game Play.

If and when people play games, they have an experience. It is this experience that a game designer cares about; because without the experience, the game is worthless. Experiences are so much part of human beings, they are hard to think about–even thinking about experiences is an experience. Although everyone is familiar with experiences, they are quite hard to describe. You can’t see them, touch them, or hold them; above all else you can’t really share them. So each person’s experience of something is completely unique, no two people can have identical experiences of the same thing.

To put it straight: The digital game itself is not the experience. The game enables the experience. So what we do, when we are talking about wrapping educational theory, we think about game design, we create artifacts (sets of rules, game boards, computer programs, ...) that are likely to create certain kinds of experiences when human players interact with them. As a design methodology, we deploy storyboarding (Jantke and Knauf, 2005).

In figure 3, we imaged an extract of the high level graph of the designed game experience in "Catch 22".

4.4 Wrapping Educational Theory Bottom-up

The argument mapping is embedded into game play. Motivated after a conscious decision was made in a dilemma-situation, it promotes clarity and insight, more detailed and complete articulation, and more deliberate evaluation. We use argument mapping to help students to understand how arguments are constructed, and how they can enhance their reasoning skills, by bringing visual clarity to complex issues.

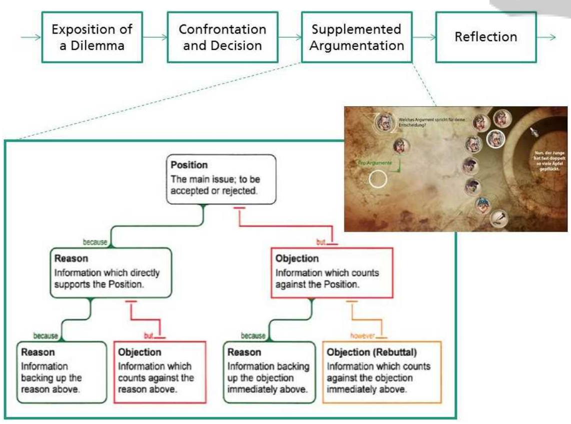

Figure 4: Expansion of an Episode by an Argument Map.

Argument mapping (van Gelder, 2013) can be an effective way to improve general critical thinking skills. Argument mapping can also promote rational reasoning in complex situations and help making better decisions in the future.

The *argument mapping technique* itself is simple but it is not easy, because it is just a visual discipline for clarifying our thinking. And clarifying our thinking is not easy, even with visual discipline.

To illustrate the issue presented, see figure 4, and notice that mapping makes it clear which statements serve as the main conclusion, which serve as reasons to believe that conclusion, and which statements are intended as objections to which claims.

5 CONCLUSIONS & OUTLOOK

Even nowadays, far too many systems of technology-enhanced learning serve mostly administrational purposes such as providing documents to learners and bookkeeping by teachers. There is a rather wide consensus that educational theory needs to be more systematically encoded into digital systems of technology-enhanced learning such as, for instance, serious games.

When storyboarding à la (Jantke and Knauf, 2005) is deployed as a design methodology, educational theory may be reflected syntactically.

For illustration, have a look at the cutout of the "Catch 22" storyboard on display in the upper part of figure 4. The linear sequence of four episodes of game play reflect the sequence of upper nodes in the visualizations of Haidt's *social intuitionist model* as shown in figure 2.

To put it straight: some pedagogy becomes visible and, therefore, the difference of varying educational theories deployed may become visually perceivable.

This opens unprecedented options of debating didactics and of experimenting with varying didactic approaches.

The *storyboard interpretation technology* makes those experiments operationally feasible, but it needs some further completion to allow for systematic routine applications as sketched in (Arnold et al., 2013) including the development of authoring tools.

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