Talking Digital Educational Games

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Abstract. A common understanding, a common language is an essential requirement for a successful evolution of educational games. A taxonomy that defines terms and, more importantly, sets boundaries and relationships between terms and concepts is deemed to be a necessary step towards a global integration. Moreover, such type of classification serves the avoidance of misunderstandings and myths about games. Therefore, we present a taxonomy of adaptive and adaptable digital educational games, including classifications, hierarchies, and rules. The questions may rise why a framework of educational adaptation is the appropriate context for this kind of taxonomy. The reason is simple; to realize adaptation and personalization it is necessary to know what can be adapted and in which way and in which context, under which regularities, and under which constraints. This is particularly true since "play" is a rather novel factor in educational adaptation and personalization.

The Playing Man

To elucidate the area of digital educational games, we do need a context description of computer / video games per se. Moreover, we have to define what a computer/video game is. Several definitions, taxonomies, and classifications have been proposed.

First, the term game: A popular definition came from the Dutch culture-anthropologist Johan Huizinga in his famous work *Homo ludens* ([1], p.132). He stated, a game "*is an activity which proceeds within certain limits of time and space, in a visible order, according to rules freely accepted, and outside the sphere of necessity or material utility. The play-mood is one of rapture and enthusiasm, and is sacred or festive in accordance with the occasion. A feeling of exaltation and tension accompanies the action, mirth and relaxation follow*". This definition is old, we grant, however, it comprises the most important aspects of games, that is, gratuitousness, enjoyment, rules, and the absence of a purpose. Reversely, this definition is frequently interpreted as if an act has some specific purpose or is conducted by external pressure, it is not a game. This, however, is problematic when it comes to serious games or educational games, which are purposeful and therefore paradox.

Ludwig Wittgenstein [2], emphasized that such simple approach to defining what a game is, fail to comprise the entire concept. Wittgenstein argued that it could not be

contained by any single definition; rather games must be considered a "fa*mily resemblance*" of a series of definitions.

A more recent approach came from Chris Crawford [3] who tried to describe the term game along several dimensions such as art, entertainment, play, interaction, etc. This approach may be summarized as an interactive, goal-oriented activity within which players (including virtual characters) can interfere with each other. An attempt to formalize the definition of game on the pillars of challenge, conflict and play came from [4]. These authors argue that the main components (the pillars) are linked together in a subtle way by the representation form (medium), by rules, by the goal definition, and by the absence or presence of opponents (Figure 1).

If we summarize this and many other old and recent definitions, we return to the aspects of Johan Huizinga. A game is characterized by gratuitousness, enjoyment, rules, and the absence of a purpose. A special case is serious games or educational games. In such cases the aspect of the absence of a specific purpose and - in parts - the voluntariness, must be re-considered. An issue we want to point out is the fact that, in an evolutionary and anthropological sense, playing is a purposeful activity, already in animals. The act of playing has the purpose of practicing certain skills, which in turn, closes the circle towards educational games.

Second, computer and video games: The major difference to "traditional" games is the medium with which a computer or video game is transmitted – "a game that is carried out with the help of a computer program" ([4], p. 3). Similarly, we can argue that a video game refers to games that are carried out through game consoles or gaming machines. This distinct might be detailed by referring to input devices ranging from computer keyboards to specific input devices (such as game pads, Nintendo's new Wii controller, or camera controlled inputs). Over the past 40 years, a tremendous diversity of computer game types emerged. This diversity including a broad range of overlap makes it difficult to establish a sound taxonomy of computer games. An early approach came from [3] He differentiated two main categories, the skill-and-action games and strategy games. The skill-and-action games are characterized by real-time play, heavy emphasis on graphics and sound, and use of joysticks or paddles rather than a keyboard. Sub-categories are combat games, maze

Fig. 1. A model of the game concept (Image taken from [4], p.2).

Fig. 2. Example for skill-and-action games according to Crawford (1984): Asteroids, Halo 3, Pac-Man, The Chronicles 2: The Eternal Maze, Fifa Soccer 08, Need for Speed Carbon.

games, sports games, paddle games, and race games (see Figure 2 for examples). The second group, the strategy games, is characterized by an emphasis on cognitive and strategic thinking instead of confrontation or manipulation. Sub-categories are adventure games, role-playing games, strategic war games, games of chance, simulation-type games, and interpersonal games.

A more up-to-date classification of today's computer games is given by [5]. He distinguished six categories (see also Figure 3):

- Action Game
  This kind of games focuses on interactive gameplay and requires fast reflexes and hand-eye-coordination. Among others, sub-types are shooters (ranging from Space Invaders to modern first person shooters), fighting games (e.g., Tekken), survival games (e.g., Silent Hill), or the classic arcade games (e.g., Super Mario).

- Strategy Games
  Strategy games focus on analytical thinking, reasoning, planning. This genre is classified by three sub-categories, turn-based strategy games including minor action components (e.g., Civilization), real-time strategy games (e.g., SimCity), and massively multiplayer online role playing games (e.g., World of Warcraft).

- Adventure Games
  This kind of games focuses on the interactively experiencing narratives. The gameplay itself is, as in strategy games, dominated by cognitive/reasoning aspects. Examples are Lineage or Asheron's Call.

- Simulation Games
  Simulation games are attempting to re-play real or fictitious situations. Generally, such games do not rely on a narrative but put the active (steering) aspects in the foreground. Examples range from Lunar Lander (Atari, 1979) to Microsoft's Flight Simulator. A special sub-category is sports games / sports simulations (e.g., Fifa Soccer 08 or Formula 1 Racing). Another special category is business simulations.
- Puzzle Games
  including matching or constructive puzzle or game play types like Rubik's cube.

- Educational Games
  including simple games for young children, drill-and-practice games.

This taxonomy, however, is quite unsystematic and also incomplete. Certain competitive games genres (competitive sports games) are lacking and so do "analogue" games such as card games, chess, or games of chance. An important systematization of the classification of game genres was made by [6] This approach begins with a classification of games on a 'plane' of ludology, narratology, and degree of reality (the author terms this 'simulation' or 'prosthetic reality'). In a next

Fig. 3. Example games (from top right): Space Invaders, Tekken, Silent Hill, Civilization, SimCity, World of Warcraft, Lineage, Lunar Lander, Flight Simulator.

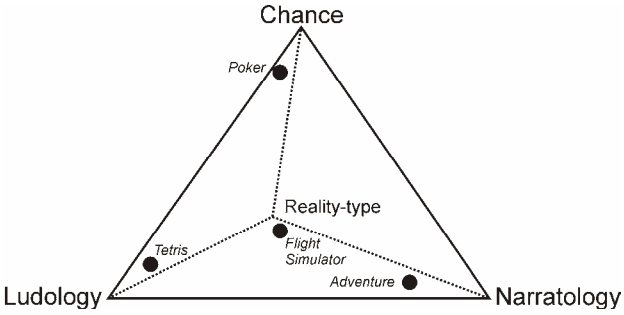

Fig. 4. A three-dimensional classification of games (Lindley, 2003).

step, the model is extended by a 3rd dimension, that of chance (the author terms this 'gambling' or 'decisions about gain and loss'). The model manifests as a three-dimensional pyramid, which allows for classifying game types along its dimensions (Figure 4). Although Lindley's taxonomy offers a systematic approach that covers a wide range of aspects, the purpose aspects is not represented very well. Particularly educational aspects and intentions establish a micro universe of educational game types. The current state-of-the-art can be classified by following categories based on the psycho-pedagogical and technical level of games [7].

- Mini Games for Young Children
  The most common and likely most successful form of educational games are mini games for the preschool age and the primary education level (Figure 5). Generally, those games are based on Flash or Shockwave technology, are distributed through online platforms, and have a child-oriented comic-like design and game-play. In many cases they are associated with characters known from movies, television series, or books. Essentially, the games attempt to teach young children basic knowledge and skills like knowing numbers, letters, simple math, reading, or biology – just to mention a few. Often the game genre is based on trivia, puzzle, memory, or drill and practice (in a positive sense) styles. These games are very successful; they are entertaining and instructional for their target audience.

- Simulation Games
  Simulation games basically pursue a drill and practice approach to certain procedural, strategic, or tactic skills. The instant feedback and risk-free environment invite exploration and experimentation, stimulating curiosity, discovery learning and perseverance [8]. The game character and intensity are varying depending on the context and application. Flight simulators, for example, are used in professional pilot training but almost the same simulations are sold for pure gaming or edutainment purposes (e.g., Microsoft's Flight Simulator). Further examples are military training promoting simulation (games) for practicing specific warfare skills or simulations in medical training (e.g., to enable surgery training in safe

virtual environments). From a technical perspective, simulations and simulation games are on a high level; from an educational perspective, simulations are generally virtual representations of the real world and sparsely implement – if any – sound didactic or pedagogical strategies.

- Off-the-Shelf Games / Moddings
  A third approach to using games for educational purposes is using commercial off-the-shelf games. A prominent example is "Teaching with games", which was a one-year project by Futurelab (www.futurelab.org.uk). Basically, the scope of the project was to research the capabilities of off-the-shelf games for application in schools. The educational objectives of using such games, however, are limited, basically comprising the promotion of collaboration, fostering engagement and motivation, and developing thinking skills. In many cases off-the-shelf games are used as supplementary material or as incentives for learning.
  Modding (a term for modifying software or hardware) is an extension of the off-the-shelf approach. In such cases commercial games are modified using level editors in order to realize certain educational objectives (cf. [9]). An example is the Revolution (Figure 5), a modding of the game Neverwinter Nights, which is supposed to teach and illustrate social aspects of history [10].

- Game-like Enhancements for Learning Material
  A large part of educational games applied successfully in practice is game-like enhancements to digital learning material; [9] classified such games as "tools". Generally, such approaches incorporate sound instructional theories and provide goal-oriented learning situations (LeS). However, in most cases the level of educational objectives, narrative, game-play, and audio-visual realization is limited. In other words, such approach incorporates small games as training for a specific limited set of skills.

- Competitive Educational Games
  What we mean with competitive educational games is games with a primarily educational purpose that – at the same time – can compete with commercial entertainment games as well as with conventional learning environments. Such games are characterized by a convincing narrative and game-play, an appealing audio-visual design, sound instructional design, and clear educational objectives. The most significant characteristic of such games is that learning is embedded in the narrative and the game-play. Among the most advanced learning games are Peacemaker, a commercial game simulation of the Palestine conflict, designed to promote dialog and understanding (www.peacemakergame.com), or NanoMission (Figure 5), a scientifically accurate 3D action adventure teaching nanotechnology through real world practical applications ranging from microelectronics to drug delivery (www.nanomission.org).

Fig. 5. Screenshots of current approaches to educational games (from left to right): A math picture puzzle for young children, the modding Revolution, and the educational game NanoMission.

Based on this brief review of game classifications and taxonomies, the question arises if the existing formalized, systematic taxonomies suffice to provide us with an understanding of the game context and its possibilities, requirements, and difficulties in psycho-pedagogical and motivational-emotional adaptation. The answer must be no. Several authors raised a variety of aspects, however, forgot other aspects. Moreover, a computer-understandable systemic approach is lacking that - at least - includes the aspects of a game's purpose.

To realize this systematic and formal taxonomy, we rely on the aspects raised by previous authors (reviewed here) and propose a collective *hyper-cube taxonomy*. This approach is characterized by an *inner three-dimensional classification core* (Figure 6). This core involves the dimensions:

- **Purpose** – ranging from *synthesizing fun or enjoyment* (or vice versa reducing boredom) to *particular training (learning) purposes*. While the former is straight-forward and mentioned by all existing classifications, the latter aspect is not very common. We want to base this idea on evolutionary theory and animal behavior studies (e.g., that of Konrad Lorenz), that revealed that play is a central learning mechanism in animals.

- **Reality** – ranging from *imitation* of real and fictitious contexts (this includes for example real world simulations but also realistic and credible depictions of fictitious fantasy game worlds) to proving *abstract visualizations* such as in games like *Tetris*.

- **Social Involvement** – ranging from single player games to massively multiplayer games such as *World of Warcraft* or *Second Life*).

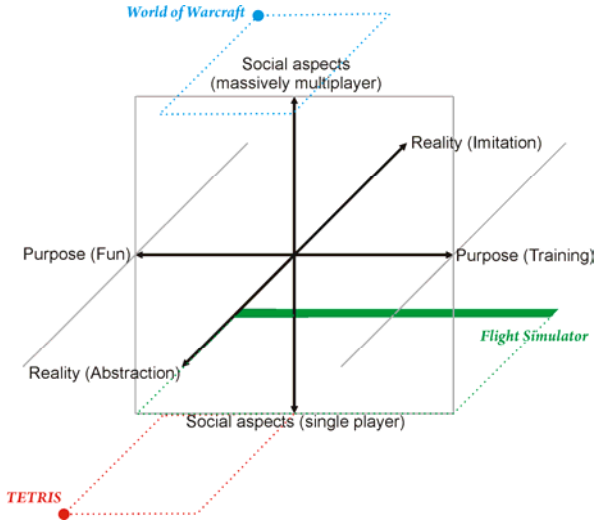

Fig. 6. Inner classification core of the proposed hypercube taxonomy.

This three-dimensional model, in another step, can be extended along the dimensions establishing a four-dimensional hypercube (Figure 7). Therefore, we propose an **activity** layer, ranging from *active game types* (e.g., action games or – even with a physical dimension – the *Nintendo Wii* game play) to *passive game types* (where at the end of this continuum the passive perception of a movie is situated). The continuum not only comprises different general game types but also the amount of passive elements within certain game genres (e.g., an action game can have a high percentage of cut scenes or it might abstain from such movies at all.

Unfortunately, such complex model is not very easy to be overlooked by humans to its full extension. Therefore, the classifying aspects of the hypercube model and the intertwined relationships might be presented with the metaphor of a *property panel* we are all familiar with in several software applications. Such representation is shown in Figure 8. The classifying layers are view, activity, role-play, realism, abstraction, speed, narrative, player, rules, driver, device, motivation, openness, and purpose all located on a bi-polar continuum, which is represented in form o slider controls. All possible combinations of slider settings (which are an infinite number) impose a infinite number of game genres.

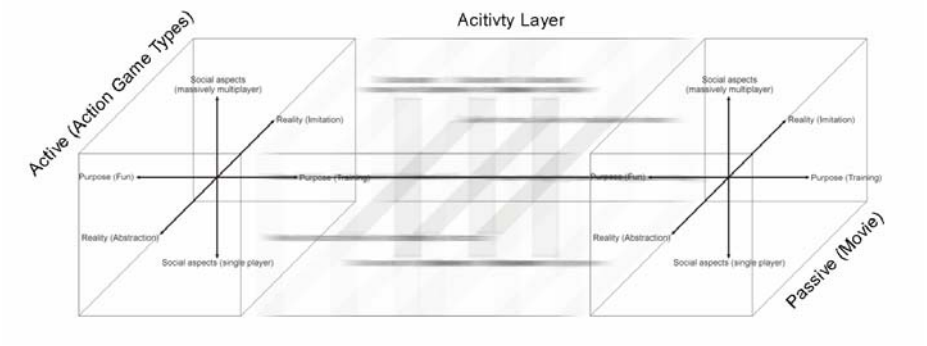

Fig. 7. The hypercube extension of the inner core model. To the left end of the continuum the (even physically active) Nintendo Wii gameplay might be located, at the right and the passive perception of a movie.

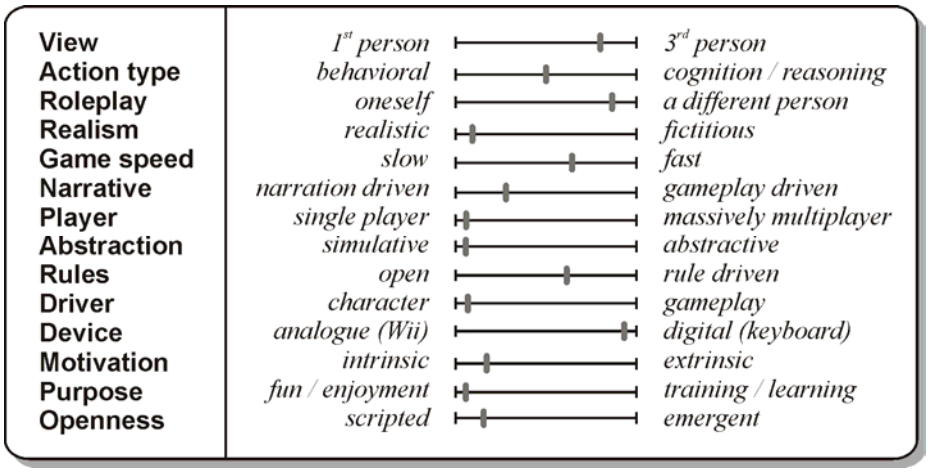

Fig. 8. The hypercube taxonomy model represented in form of a property panel with slider controls. The different layers can be seen as bi-polar continua. This figure shows the famous game series Tomb Raider as an example.

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