Educational Gamification & Artificial Intelligence

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Educational Gamification & Artificial Intelligence

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Version 1.00
17.12.2018

ÖFFENTLICH / PUBLIC

03-2018

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Impressum

ADICOM TECH REPORT

ISSN (Print) 2627-0749
ISSN (Online) 2627-0757

ADICOM Software KG
Frauentorstr. 11
99423 Weimar

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Geschäftsführer: Christian Hölzer
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Cover Page Design: Robert Krause
Picture Credits:
World Map 45° Lines Vector
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https://www.vecteezy.com/map-vector/24225-world-map-45-lines-vector

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No Educational Gamification design
without understanding Game Play and
no Educational Gamification application
without mastering Artificial Intelligence.

Preface

Educational Gamification and *Artificial Intelligence* are the key buzzwords as well as the key research and development areas considered throughout the authors' present technical report. Both *Gamification* and *Artificial Intelligence* are currently en vogue[1].

The authors are aiming at an integration of Artificial Intelligence (AI) knowledge, principles, methodologies, and technologies into the practice of Educational Gamification (abbreviated by EG within this report). To Educational Gamification that shall succeed, Artificial Intelligence is inevitable. The report is intended to clarify why this is the case and how AI enables effective EG.

As a prerequisite of this study, the authors need a brief conceptualization of both AI and EG. Due to AI's greater maturity, it is easier to define AI than to agree about EG. To keep the report balanced, the authors confine themselves to only a short discussion of gamification and direct the interested reader to [Jan 2018] for a more comprehensive investigation.

The authors' ultimate goal – besides the side-effect of better conceptualizations – is to make the attractiveness and fascination of digital games accessible to education by means of AI. As the second author put it[2] in [Jan 2018], page 2, "man stelle sich vor, es gelingt, Lehr-, Lern- und Trainingsangebote derart zu gestalten, dass sie 'süchtig machen'. Lerner wollen immer wieder mehr und mehr lernen, Trainees können gar nicht aufhören zu trainieren, und diejenigen, die lernen und trainieren, bilden im Internet Gruppen (auf Neudeutsch: Communities), in denen sie sich über ihre Erlebnisse und Erfolge beim Erwerb von Wissen und Fähigkeiten begeistert austauschen und andere anregen mitzumachen. Man stelle sich vor, Schulbuchverlage bringen Lehrmaterialien mit Suchtcharakter heraus und die Schule wird zum Lieblingsort unserer Kinder."

[1] The German Federal Government has recently published its so-called *Artificial Intelligence Strategy* (see https://www.bmwi.de/Redaktion/DE/Downloads/E/eckpunktepapier-ki.pdf?_blob=publicationFile&v=10) dated July 18, 2018. Another recent press release of Novemer 16, 2018, at https://www.bmwi.de/Redaktion/DE/Pressemitteilungen/2018/20181116-bundesregierung-beschliesst-strategie-kuenstliche-intelligenz.html provides a few further details accompanied by a dedicated web page https://www.ki-strategie-deutschland.de/home.html surveying a so-called "National Strategy for Artificial Intelligence". This report is the authors' very first response.

[2] English interpretation by Tim Hume: *Imagine – if successful – teaching, learning and training offers that are addictive. Learners always want more and learn more, trainees cannot stop to train, and those who learn and train, form communities on the internet where they exchange their experiences and successes in acquiring knowledge and sharing skills, as well as inspiring others to participate. Imagine, textbook publishers producing educational materials of an addictive nature and where school becomes our children's favorite venue.*

Was wir über unsere Gesellschaft, ja
über die Welt, in der wir leben, wissen,
wissen wir durch die Massenmedien.
[Luh 1996], p. 9

Was wir über Künstliche Intelligenz wissen,
wissen wir aus digitalen Spielen.

1 Essentials of Artificial Intelligence

Those who play digital games do not need any introduction into Artificial Intelligence–they know about AI, at least, they think so. The games magazines are full of debates about the quality of AI implemented in digital games. In letters to the editor, players contribute a lot to the debate. The imputation of AI to games dates back to the first person shooter UNREAL TOURNAMENT, 1999, at least. However, AI is much more involved than what the majority of players imagine.

For the present purpose of effective EG, we need a more substantial understanding of AI. There are introductions into AI galore such as [GJT 1989], [Nor 1992], [RN 1995], [LC 2008]. [Ert 2013], [GN 2015], [RN 2016], and [Kap 2017],

Unfortunately, the majority of authors overlook that the fundamentals of AI date back more than 300 years to the pioneering work of Gottfried Wilhelm Leibniz who did already believe in the appropriateness of logical representation and of formal reasoning even for philosophical debates. Leibniz anticipates two philosophers concluding a heated debate with the conciliatory word *calculemus*–let's find out the truth computationally[3], Leibniz's vision of a far-reaching AI.

Based on his own development of a mechanical calculator for all four operations of arithmetic, Leibniz understood that the *automation of reasoning* requires, first, a *knowledge representation* – in Leibniz's terminology, a *lingua characteristica* – and, second, an *inference meachnism* – a *calculus ratiocinator*.

Based on knowledge representations and inference mechanisms, one may implement systems that achieve varying results that, otherwise, would require human intelligence, to some extent. This does not mean to *simulate* human thinking. Computers think in another way than humans do, very much like airplanes are flying, but differently from the way in which birds do so.

In the spirit of Leibniz, Gottlob Frege developed his so-called Begriffsschrift [Fre 1879] to provide us with an expressive formal language. As indicated by the term "reines Denken", i.e. pure thinking, in the title of his book, Frege understood his work as a contribution to a realization of Leibniz's program toward an automation of reasoning. After a certain polishing, Frege's language is nowadays known as the language of the first order predicate calculus suitable for many far-reaching applications. By way of illustration, the perspective developed here has been used for an AI approach to *interactive digital storytelling* [Jan 2010].

For the purpose of Educational Gamification powered by Artificial Intelligence, the authors adopt this understanding of AI which is usually called the *symbolic* approach as opposed to the *subsymbolic* one. Symbolic Artificial Intelligence deals with knowledge representations that are readable *both* by computers and by humans. For purposes of education, this is deemed important.

In subsymbolic AI, one is satisfied with knowledge representations accessible by computers.

[3] The Latin original can be found in [Ger 1875–1900], at the bottom of page 200: *Quo facto, quando orientur controversiae. Non magis disputatione opus erit inter duos philosophos, quam inter duos computistas. Sufficiet enim calamos in manus sumere sedereque ad abacos, et sibi mutuo (accito si placet amico) dicere: calculemus.*

Definitions of gamification tend to vary by person,
both in industry and within academia.

[LACA 2018], p. 315

2 Essentials of Educational Gamification

In contrast to Artificial Intelligence, the considerably younger field of Gamification, in general, and Educational Gamification, in particular, is much less established, as Landers et al. clarify. There are many slightly varying moderate opinions as well as extremely contradictory positions.

On the one hand, Bogost calls gamification just bullshit and fortrightly names those who advocate gamification bullshitters [Bog 2011] (see also the related appendix of [Jan 2018]).

On the other hand, there are authors like Deterding et al. who trivialize gamification to be "the use of elements of game design in non-game contexts " ([DDKN 2011a], p. 2; see also [DDKN 2011b], p. 10). If they would be right, everyone were able to implement gamification and nobody would need any scientific background to do so. That is what's driving Bogost crazy.

In particular, the use of game elements such as score points, batches, and the like[4] does not lead in any way to AI. By demonstrating the necessity of Artificial Intelligence within the development, implementation, and application of Educational Gamification, Deterding's opinion is proven incorrect or, at least, useless. Interested readers are directed to [Jan 2018] for a more detailed discussion. In the present section, the authors confine themselves to just two aspects illustrating the scientific substantiation of gamification by an understanding of human play.

Figure 1: Two Aspects of Understanding Game Play [Jan 2006a]

It seems a platitude, but even if so, it is definitely an important one: Every digital game is simultaneously (i) an IT system, (ii) entertainment media, and (iii) highly interactive. Humans preceive media always within a personal context of previous knowledge, experience, preferences, anxieties, and the like. Consequently, there is no game that attracts everyone. What works well for the one, fails for the other. (iii) names the entrance point of AI, because human-computer interaction data are rich enough to learn about a human player and to adapt to the player's needs and desires computationally [AJ 2018]. Digital games have a constitutional relationship to AI.

Who agrees to play a game (or to engage in gamified learning) (a) performs an act of framing accepting (b) some rules of play and being aware of some predefined implemented mechanics. The experience of play is only pleasant, if there is an elaborated balance of (c) self-determination and (d) indetermination. Players who really engage in playing learn about the rules and the mechanics and, thus, change the balance to more self-determination. This provides satisfaction, but also causes a problem known to the games industry as replay value. From the very beginning, the experience of game play depends on many player prerequisites such as knowledge and skills. And it changes over time.

Different players experience game play differently and effects of learning are largely varying.

[4] Interested readers might wish to have a look into [BH 2005] for more concepts and technicalities.

3 Gamification & AI – Current Perspectives

Even very recently[5], the majority of studies in which gamification meets Artificial Intelligence appear only cursory. The unsatisfactory state of the literature bears anbundant evidence for the urgent need of more systematic investigations.

Interestingly, authors who clearly identify the importance of AI to education do not see any substantial relationship to gamification [CKKB 2018], except the nonsense formulation that "gamification elements such as leader boards and points can be helpful to record students' progress and solving the problem of balancing pupils speed of understanding new academic material" (ibid., p. 21). These authors' apparent misunderstanding of gamification leads to a confusion of conventional learner modeling by means of old-fashioned overlay models (see, e.g., the 10 most recent UMAP conferences [HPZ 2009], [DBKC 2010], [KCMO 2011], [MMDN 2012], [CWMS 2013], [DKC$^+$ 2014], [RBCL 2015], [VBAD 2016], [Bie 2017], and [Mit 2018]) with AI.

Vice versa, others who deal with gamification for purposes of education miss AI [KWUS 2018]. And in rare cases where authors dealing with gamification for e-learning see AI as an important or, at least, interesting approach, they exclude it explicitly from investigation and expect it to play a role only in the future ([UVJP 2018], p. 395).

Last but not least, Chou offers a quite comprehensive treatment of gamification [Cho 2016]. His book's title promises explicitely to go "beyond points, badges and leaderboards", but the author has severe difficulties in doing so. "In my own view, gamification is the craft of deriving fun and engaging elements found typically in games" (ibid., p. 8). Here they are again – the fun elements, the engaging elements, ... and bashfully concealed the points, the batches, and the leaderboards.

But human experience – fun, thrill, fear, excitement, disappointment, and whatsoever – is not just a bundle of elements; like a story is not just a sequence of words.

A bit later, Chou goes a diffident step toward experience: "Through gamification, we can look through the lens of games to understand how to combine different game mechanics and techniques to form desired and joyful experiences for everyone" (ibid., p. 10). This is the point at which Bogost interferes and calls the statement a *bullshit* and authors of utterances like this *bullshitters* [Bog 2011].

The reader is invited to check the above pretention of *joyful experiences for everyone* for its reliability, especially seen in the light of the insights sketched in section 2.

It goes without saying that gamification literature as well as investigations into the relationship of education and AI result in confusing and irritating claims. It is not easy and, perhaps, fruitless to conduct research regarding the cause of this highly unsatisfactory state of affair, but a few reasons seem to be obvious.

- A majority of educators are still reluctant to game-based learning and to games, in general.
- Those knowledgeable in the digital games area usually have a trivialized and incomplete understanding of AI.
- Scientists and engineers in AI are usually not aware of the depth of digital games studies and frequently do not appreciate the methodologies of the humanities.
- The trivialized approach to gamification as the usage of game elements such as score points and the like is easy to memorize and, therefore, erroneously adopted with baneful effects.
- Last but not least, there are commercial and other reasons for untrustworthy promises.

[5] The present authors confine themselves exclusively to most recent publications not older than one year.

Gamification bedeutet, in einer Domäne dem Menschen
neue Interaktionsmöglichkeiten zu schaffen,
die das Potenzial haben,
ihm spielerische Erlebnisse zu ermöglichen.

[Jan 2018], p. 8

4 Educational Gamification Powered by Artificial Intelligence

Understanding digital games and game play is an inevitable basis of Educational Gamification. How can you imagine a consultant who does not know anything about digital games and who has no experience of playing them, but tells you in detail how to implement gamification . . . ?! Typically, *gamification is transformation* as exemplified in [FBJ 2015]. As such, it is based on prior knowledge, competencies, and educational practice (see [Jan 2018], chapters 7.2 and 7.3).

4.1 Educational Gamification beyond Game Elements and Mechanics

Digital games are fascinating a steadily growing audience. For years, the digital games market is already outperforming the motion picture business by far. And there is no doubt at all that digital games have the potential of being addictive. The goal of Educational Gamification is to unlock the attractiveness and the addictive potential of digital games for the purpose of more efficient and effective learning and training.

Digital games are entertainment media with the potential to provide human players with fascinating experiences of play. Touching and satisfying experiences may be induced by a variety of psychological factors such as satisfaction of overcoming a difficulty, of solving a problem, or of escaping from a dangerous situation. There may be thrill or surprise involved. The film business knows about techniques of dramaturgy such as *Mitaffekt*[6] and *Eigenaffekt* masterly deployed, e.g., by Alfred Hitchcock. [Jan 2006b] relates film and digital games dramaturgy (ibid., section 5.5, see also [Jan 2015]).

Interactions with non-player characters (NPCs) may result in parasocial experiences that are non easy to distinguish from social experiences in multi-player games.

Looking back at the three constitutional aspects of digital games (see section 2 on page 3), an intense experience according to (ii) makes the game control according to (i) seemingly disappear. A player – even a learner – in *flow* [Csi 1975] does not control a digital system via some interface and does not struggle with technicalities, but enjoys touching experiences in a virtual world[7].

Educational Gamification means the transformation of given learning or training material and/or educational environment into a form that bears the potential of playful experiences that are likely to unfold when humans accept to engage.

Due to the very nature of digital games and game play, the results of gamification – be it educational or not – are perceived vy varying humans differently. Accordingly, the learning and training effects may be largely varying.

[6] Mitaffekt and Eigenaffekt are terms used in German systematic film analysis [Rab 1999]. It seems that there are no comparable terms in English. In the authors' own words, Mitaffekt means that a spectator is affected together with the acting character in the movie and Eigenaffekt means that a spectator anticipates more than the character in the movie. She would like to yell something like "don't go there", "don't do this", or anything like that. But the character in the movie does not listen to the movie audience.

[7] The authors refrain from a detailed discussion of pervasiveness and direct the reader to [Jan 2018], instead.

4.2 The Need of Artificial Intelligence for Educational Gamification

Educators who feel the necessity to respond to the digitalization of literally all spheres of human life and who understand the attractiveness of digital games want to reach as many of their learners and trainees as effectively as possible. But the perception of gamification results varies.

The one and only answer is to improve Educational Gamification by Artificial Intelligence.

AI has the concepts and methodologies to make digital systems learnable. Grounded on AI, a digital system may be equipped with the ability to learn about its user's perculiarities such as, e.g., a player's intentions, a learner's misconceptions, and human's current mood. [Jan 2014] and [JSS 2016] illustrate the corresponding power of AI by means of a digital game case study.

Artificial Intelligence that makes a digital system able to learn about users is the key to make Educational Gamification adaptive and, thus, more effective to varying human learners and trainees.

Personalization by means of adaptivity together with attractiveness based on playfulness makes gamified education advantageous over conventional approaches as can be seen case studies such as [HHJ 2010], [KJ 2014], and [JB 2015].

4.3 Konzepts and Technologies of Artificial Intelligence Implementation

The main difficulty of gamification, not only in educational applications, is to anticipate human experiences. This is a problem of dynamic planning in which alternatives must be foreseen [AJ 1996].

The key technology of planning possibly varying user experiences is *storyboarding* [JK 2005][8] [9]. *Storyboards* must be digital to allow for a direct usage in the designed system's implementation.

Formally, storyboards are graphs, more precisely, they are hierarchically structured families of graphs. The approach is appropriate to realistic training applications of high complexity [AFJ 2013a, AFJ$^+$ 2013b].

In storyboard graphs, it is custom to distinguish two categories of nodes: scenes and episodes. Scenes are elementary nodes that have a semantics in the application domain such as, to name a few, a cut scene, a document offered for download, a text to read, an audio file to listen to, or alternative buttons to select from alternative opportunities of continuation. Episodes are placeholders for varying subgraphs to be substituted. Every episode brings with it substitution conditions for the varying subgraphs. The conditions refer to variables of the interaction history, the context of application, and the human user profile (see [Jan 2012b], [Jan 2012a] for details).

Storyboards form the syntactic basis of what is called *storyboard interpretation technology*. The technical term names the operational concept of interpreting storybords at execution time, i.e., at learnimg, training, or play time. In this way, dynamic adaptation is realized based on the data referred to in the substitution conditions.

Alternative graph substitutions for episodes may represent alternative didactic concepts. The graphs represent varying pedagogical concepts that can be seen as *patterns* according to the conceptualizations ranging from [Ale 1979] to [Ang 1980].

The approach has been proven practically successful (see the research from [Jan 2006c] through [Jan 2009] to [Jan 2013]). By means of the underlying storyboard concepts, storyboarding, and storyboard interpretation technology, AI paves the road to effective EG.

[8] In this basic paper, the authors explicitly emphasize that storyboarding is "the organization of experience" (ibid., p. 25).

[9] Both [AJ 1996] and [JK 2005] are based on the concepts and on the algorithmics developed in [Arn 1996].

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