Gamification of Education: Usage of Game Mechanics to Enhance the Learner Knowledge Adoption

Marko Suvajdzic
University of Florida
Dragana Stojanovic
Singidunum University

Gamification is the application of game-design elements and game principles in non-game contexts. Through the gamification of education, technology is working on improving and scaling education. Video games allow for individual participation of all learners, and thus are a valuable tool in the system of education. Furthermore, the emergence of gamification of learning is one of the major results of the increased use of technology in education.

Games have been used as a form of entertainment, as well as a tool for learning, for thousands of years. The increased sophistication of video games provides for improved entertainment experience, and an increased ability for players to retain the information communicated during a game. While some games are created with the goal of educating, the vast majority of games are created for entertainment purposes only. However, regardless of the intent behind their creation, the learning process takes place, whether it is intentional or not. The only difference is in what is being learned, and how that new knowledge is perceived and categorized in the player's mind.

The early evidence, both anecdotal as well as scientific, suggests that interactive virtual environments work. Based on this initial research, it seems as if interactive virtual environments are changing the way in which we learn, and that those exposed to it are having measurable and concrete increase in academic scores.

Through the use of such tools, young people are engaged in an exploration of language, games, social interaction, and self-directed education that can be used to support learning. They are different as a result of this use of digital media, and these differences are reflected in their sense of self, in how they express their independence and creativity, and in their ability to learn, exercise judgment, and think systemically.

Earlier Debates: Media in Education

Speaking of media and technology usage in the process of education, teaching and learning, we must go back to some of the early discussions of this fusion and its potentials. Much of the discussion about the role of virtual worlds, gaming and IT in education today is reminiscent of the conversations that have happened earlier in the 20th century on the topic of education and media. Certainly, there were always those educators who

claimed that gamification, distance education or learning within virtual worlds is the best way to learn. However, most who have studied the impact of technology on education would agree that all of these different approaches make but only a part of the whole that goes into the process of transferring knowledge, and that such options are just but the few that would be available to a learner at any given moment. Speaking in the terms of gamification in education, and looking at the research results from previous decade,[1] we can conclude, even with all the challenges to be met in the future times, that gamification can certainly lead to much better results both for the students and educators regarding the process of learning, remembering and feeling involved. However, it is important to note that it can give its best effect if combined with other educational methods. Of course, in order for this fusion to be fruitful, both traditional teaching methodology and gamification learning strategies have to work in cooperation. It means that we need more teachers/mentors who would opt for gamification in education, and, on the other side, more video game programmers who would see the field of education as an exciting new terrain for development. A different way to look at the role of technology in education is to not focus on its direct role as a benefit, but to evaluate the changes that such a shift will bring, and the secondary opportunities that will be born out of such a change.

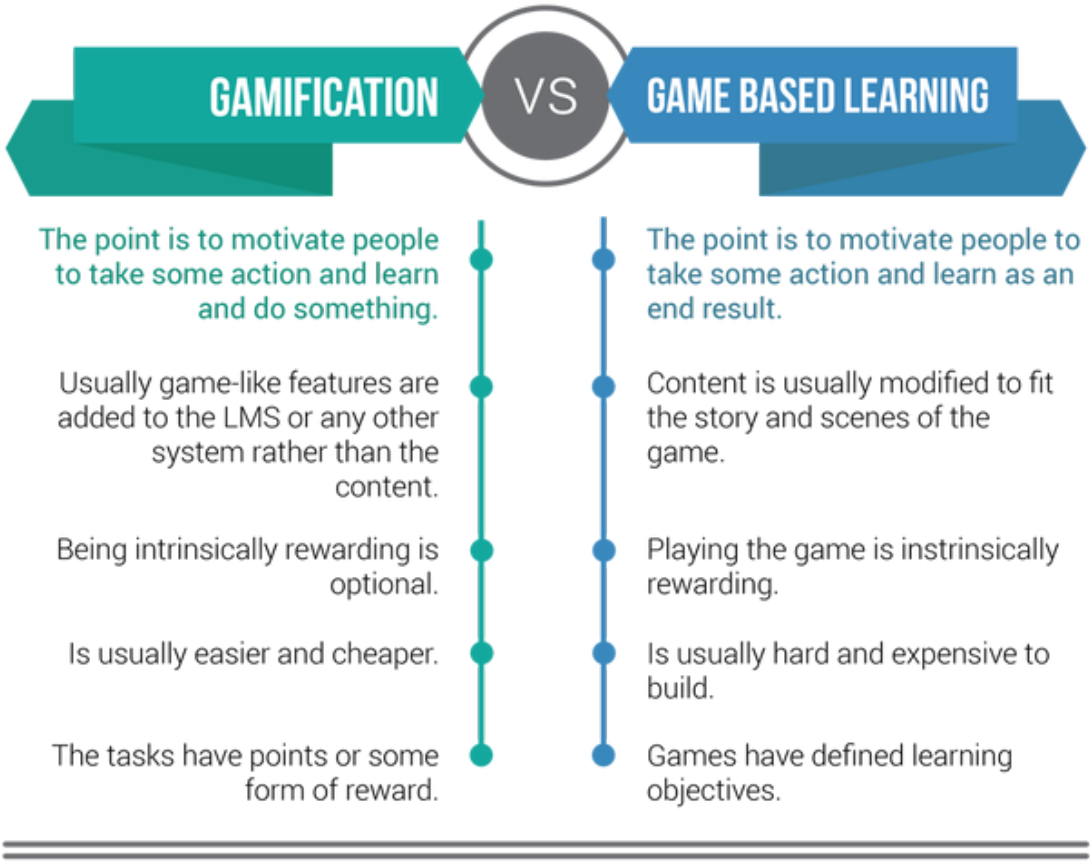
Looking back to some of the thoughts in this area from the second part of the 20th century, we can find Richard Clark's seminal work from 1983, containing now famous "mere vehicles" analogy: "The best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in nutrition… only the content of the vehicle can influence achievement."[2]

The article went on to argue that instructional media is excellent for storing the knowledge, but it had little to no influence on the learning effect. Learning was not enhanced because the knowledge was media based, but rather it was fully dependent upon its own quality. Thus the role of media was delegated to a subservent and frivolous role, and the author urged the academia to "give up your enthusiasm for media effects on learning", which was also a theme of one of his follow up publications.[3] His words became a rallying cry for those who opposed the value of media in education for years to come.

Another pioneer of learning technology and distance education Jim Finn from the

[1] See, for example, different but equally important conclusions in Dominguez, A. et al. (2013), Gamifying learning experiences: Practical implications and outcomes. *Computers & Education*, Volume 63, April 2013, Pages 380-392,
Biro, G. I. (2014). Didactics 2.0: a pedagogical analysis of gamification theory from a comparative perspective with special view to the components of learning. *Procedia - Social and Behavioral Sciences, 141*, 148–151, or Dichev, C. and Dicheva, D. (2017), Gamifying education: what is known, what is believed and what remains uncertain: a critical review, I*nternational Journal of Educational Technology in Higher Education* volume 14, Article number: 9 (2017), https://doi.org/10.1186/s41239-017-0042-5.
[2] Clark, R. E. (1983). Reconsidering research on learning from media. *Review of Educational Research, 53(4),* pg.445.
[3] Clark, R. (1994). Media will never influence learning. *Educational Technology Research and Development*, 42(2), 21-29, pg. 28.

University of Southern California compared the changes in education to the changes that another technology has created upon history. He often told the story that went like this: "The Anglo-Saxons, a dominating enemy of Charles Martel's Franks, had the stirrup but did not truly understand its implications for warfare. The stirrup made possible the emergence of a warrior called the knight who understood that the stirrup enabled the rider not only to keep his seat, but also to deliver a blow with a lance having the combined weight of the rider and charging horse. This simple concept permitted the Franks to conquer the Anglo-Saxons and change the face of the western civilization. Martel had a vision to seize the idea and to use it. He did not invent the stirrup, but knew how to use it purposefully."[4]



Finn summarized the implications of his story in the following terms: "The acceptance or rejection of an invention, or the extent to which its implications are realized if it is accepted, depends quite as much upon the condition of society, and upon the imagination of its leadership, as upon the nature of technological item itself… The Anglo-Saxons used the stirrup, but did not comprehend it; and for this they paid a fearful price… It was the Franks alone-presumably led by Charles Martel's genius – who fully grasped the possibilities inherent in the stirrup and created in terms of it a new type of warfare supported by a novel structure of a society that we call feudalism… For a thousand years feudal institutions bore the marks of their birth from the new military technologies of the eight century."[5]

[4] Finn, J. D. (1964) *The Franks had the right idea*. NEA Journal, Vol. 10. No.3.
[5] Ibid, pg. 24.

Like Clark, Finn puts forward that new technology in itself may not bring any specific advantage. However, he also proposes that it is not the technology itself that brings improvements, but that it's the specific usage of the new technology, and the new ways that are made possible by the specific technology that makes the difference. In his story, it was not the stirrup, but the knight that caused great changes in the society, and it was the stirrup that allowed the creation of the knight. In a similar vein, the virtual worlds, gamification and various other computer enabled technologies may not be the positive influence on education in themselves, but may be the building block that will allow for creation of new paradigms, that will bring about improvements that we cannot imagine from our current perspective.

Gamification: is the Teacher Present?

Gamification in education often implies an aspect of the learning process that might be worth considering: learning from a distance, which means partial or total lack of the physical presence of the teacher. Is gamification then a sort of distance learning technique?

Although the field of distance education has existed since the 1840s, the need for a theoretical base of distance education was still largely unfulfilled until the 1970s. Holmberg stated that the further theoretical considerations will provide for firm ground upon which further research will be conducted.[6] Moore, on the other hand, was concerned the future progress in the distance learning field will be hindered by the lack of macro factors. He indicated that in this area of education there was a need to describe and define the field, to discriminate between the various components of the field, and to identify the critical elements of the various forms of learning and teaching.[7] Keegan, some time earlier, reflected upon the theory of distance education and implied the continual need for its development of perfection: „Lack of accepted theory has weekend distance education: there has been a lack of identity, a sense of belonging to get the referee and the lack of a touchstone against which decisions on methods, one media, financing, student support, when they have to be made, can be made with confidence."[8] Keegan elaborated on his ideas in regards to what the theory should encompass. According to Keegan, the theory should provide the firm ground against which decisions to be made. He stressed the importance of having clearly defined terminology, processes, and definitions. He believed that only with the firm base there can be further developments of distance education, especially in regards to the ad hoc approaches, that commonly plagued the field. It can all, as a method and a problem to be discussed, be applied to

[6] Holberg B. (1985) *The Feasibility of a theory of teaching for distance education and proposed theory.* (ZIFF Papier). Hagen, Westgermany: Fern Universitat, Zentrales Institute fur Fernstudienforschung Arbeitsbereich. (ERIC Document Reproduction Service No. ED290013)
[7] Moore, M. (1994) *Autonomy and interdependence.* The American Journal of Distance Education, 8(2), 1-5.
[8] Keegan D. (1988) Theories of distance education: Introduction. In D. Stewart, D. Keegan & B. Holmberg (Eds.), *Distance education: International Perspective* (pp. 63-67). New York: Routledge, pg.63.

gamification issues in the field of education nowadays, which is why we would like to bring more opinions on the question of distance learning effectivity.

Following the mentioned path of thought, Holberg also suggested that the field of distance education has been characterized by trial and error approach.[9] He maintained that there was a lack of true theoretical work that can be used as a true guide in the development of distance education. While to many scholars, distance education represents the deviation from conventional education, Holberg argued that it was a distinct form of education from conventional education. Keegan agreed with such an approach, and he also concluded that distance education is a separate form of education from conventional education.[10] According to Wedemeyer, which might be important for both the theoretical and practical approach in using video games in the process of learning, the essence of distance education was the independence of the student.[11] This can be seen in his usage of the term *independent study* for distance education at the college or university level.[12] Wedemeyer has been very critical of contemporary patterns of higher education. He believed that many of methods and approaches were utilized, and that they failed to embrace and take advantage of monitors ologies in the ways they can alter the field of education and the perception of the institution. Wedemeyer defined the system with done characteristics that emphasize learner independence and adoption of technology as a way to implement that independence, and suggested separating teaching from learning as a way of breaking educations space-time barriers.Wedemeyer identified four elements of every teaching-learning situation: a teacher, a learner or learners, a communication system or mode, and something to be taught or learned. The most important aspect of this development in regards to the distance education he believed to be the *development* between the student and the teacher. In this light, we can start thinking about gamification in education as of the next phase of development of the communication system or mode in the process of learning, which would lead to a better development between the students and the teacher.

Also, with Keegan's concept of distance education we find the separation of the teaching acts in time and place from the learning acts.[13] Successful distance education, he believes, requires the reintegration of the two acts: the intersubjectivity of teacher and learner, in which learning from teaching occurs, has to be artificially re-created, and also, learning materials, both print and nonprint, are designed to achieve as many of the characteristics of interpersonal communication as possible. When courses are presented, reintegration of the teaching act is attempted by a variety of techniques, including communication by correspondence, telephone tutorial, online computer communication, comments on

[9] Holmberg, B. (1995) *The sphere of distance education revisited.* (ERIC Document Reproduction Service No. ED386578)
[10] Keegan, D. (1996) The foundations of distance education (3rd. ed). London: Croom Helm.
[11] Wedemeyer, C. (1981). Learning at the backdoor. Madison, WI: University of Wisconsin Press
[12] Ibid.
[13] Keegan, D. (1996) *The foundations of distance education* (3rd. ed). London: Croom Helm.

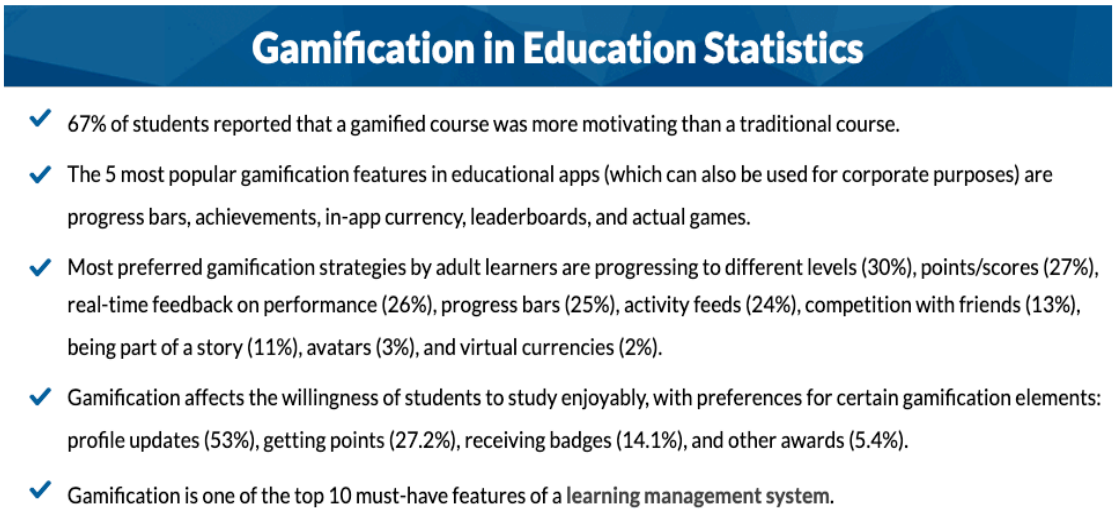
assignments by tutors orcomputers, and teleconferences. We would argue that adding gamification to this process, through using educational video games specifically designed to improve the course goals and curriculum, would logically continue this technological string through contemporary times.

Learning Online with Games, Simulations, and Virtual Worlds: Do Highly Interactive Virtual Environments work better?

Interactive environments are nothing new in the field of education. For decades, if not centuries, teachers have used short games to introduce difficult topics to students, and mock trials have been the staple at law schools for decades. In sports, athletes spend hundreds of hours practicing for every hour spent on the field. Recreating the world of competition in the form of games or mock play has been a staple of teaching practices for a long time. Some of those practices are light hearted, while some are intense and focused.

But, are the virtual worlds effective as the means of gaining knowledge? Are they just a current fad, or do they present the way of the future?

Here is one well documented example: researcher Kurt Squire tested a simulation/game called *Supercharged,* developed at MIT by John Belcher and Andrew Mckinney, to teach about electromagnetic forces. Using the pre- and post- tests with control groups, he found that the participants in the control group receiving interactive lectures improved their understanding by 15 percent over their pre-test scores, while those who played with the game improved their understanding by 28 percent.[14]



In another study, Dr. John Dunning, professor of Organizational Behavior at Troy University, discovered that students gave high marks to a course using tradional linear media. However, when he surveyed them six months later, the knowledge and

[14] Squire, K., M. Barnett, J.M. Grant, and T. Higginbotham. 2004. *Electromagnetism Supercharged! Learning Physics with Digital Simulation Games*. (Proceedings of the 2004 International Conference of the Learning Sciences). Los Angeles: UCLA Press.

theories learned were not being applied in the workplace. To test the use of simulation Dr. Dunning organized two different classes. One class used the traditional methods, based on case studies and term papers. The other class used the leadership simulation interactive simulation approach to learning. Six months later the students in the second class had a significantly greater occurances of being able to explain the material and, most importantly, being able to apply it.[15]

But Why Is This Happening?

Based on the studies conducted to date, there seems to be a consensus that the highly interactive virtual environments indeed do improve the learning process. However, it is still not clear why it is so. Here is a list of the different arguments, looking at the different components of interactivity.

Argument 1: Games as a Learning Tool

Games are the original learning tools. They have been around a lot longer than our modern classrooms. Our species has used games and simulations to pass on the knowledge since the dawn of humanity. Even today, law students sharpen their skills in mock trials, soldiers prepare for wars in mock battles, etc. Our forefather's way of teaching went mostly through this line:

- show how something is done;
- observe the student;
- correct the actions;
- allow the student to hone the skill through a series of exercises and games that motivate repetition and competition.

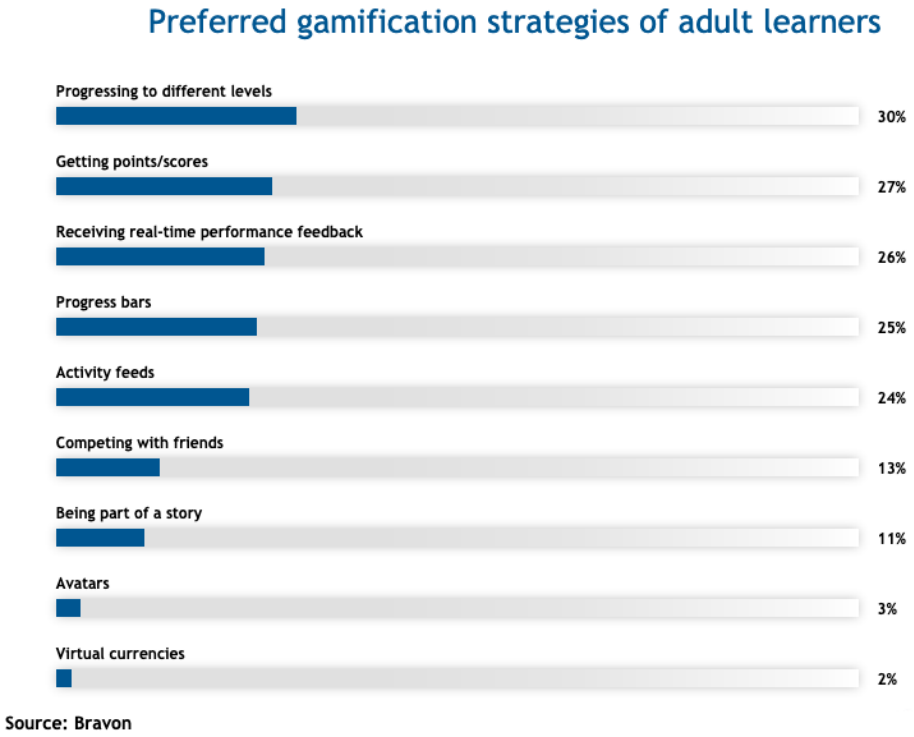
However, such approach is very difficult to scale. It requires a very low ratio between the teacher and the students, as otherwise the teacher is not capable of observing with necessary attention the performance of all his students. In the last two hundred years the number of students increased dramatically, and the traditional model of teaching was modified to fit the modern needs. So the model was changed into:

- talk about how something is done;
- students learn on their own;
- valuate with standardized tests.

Nowadays the technology is working on solving the challenge of scaling education. By

[15] Aldrich, C. 2009. *The Complete guide to simulations and serious games*. San Francisco: Jossey-Bass/ Pfeiffer.

utilizing games and virtual environments, coupled with advanced Artificial Intelligence, scientists are working on recreating the type of attention that the students of old have received, while being able to multiply it infinite number or times (as software can be installed on many machines).



Argument 2: Context and Emotional Involvement

Knowledge is useful only in context, and games and virtual environments provide the context, ideally similar to the context in which the knowledge will be eventually used.[16] For example, if we would like to teach a child about bullying in school, and how to best respond in such a situation, when stressed out and excited, it would be the best to recreate such scenarios, induce excitement, and allow the learner to play through various possibilities. This is exactly what games do, they recreate worlds and allow for player to identify himself with the virtual environments, thus providing context to any particular behavior.

When we have an emotional stake in the experience, only then our brain releases the chemicals in the amygdala and hippocampus necessary for memory.[17] It is our body's mechanism that decides what data is important and thus transformed into a memorized information versus which data is discarded. This is why it is easier for us to remember a good novel versus a bad textbook. In school we often learn the best when there is a fear present of the upcoming test. The very emotional involvement in these situations is what makes us remember better what we learned.

[16] Gee, J.P. 2003. *What video games have to teach us about learning and literacy*. New York: Palgrave/ Macmillan.
[17] Ledoux, J. 1998. *The emotional brain*. New York: Simon & Schuster.

In combining the context and emotional involvement, many have argued that failure is necessary to learn.[18] Thus creating teaching paradigms in which failure is safe is of the essence to education. Games are exactly such environments, which allow for experimentation and failure in a structured and safe format.

Argument 3: Participation

One can't learn to ride a bicycle from a great lecture, the saying goes. And what is true of riding a bicycle may be true of negotiating and strategizing, as well as other similar skills. Often the participation is a necessary ingredient in an experience, that makes us remember it afterwards. The process of converting experiential expertise into linear material such as books and lectures strips out most of what is valuable in the content to begin with.[19]

Many of us have experienced working in a group on a single computer, where on different occasions, different people would ask to take over the mouse and actively participate in creation. Or when a group of children plays a video game, often there is a desire in many of the individuals in the group to have the controller and play the game, simple watching it is not enough.

Video games allow for individual participation of all learners, and thus are a valuable tool in the system of education.

Interactive Video Gaming Content from the Students' and the Instructor's Perspective

Video games and virtual environments represent a fundamentally different approach to education from traditional learning. In analyzing the differences between the two approaches, we can divide them into three distinct categories:[20]

- How the differences in approach affect the content and its delivery
- How the differences in approach affect the teachers experience
- How the differences in approach affect the learners experience.

So far we have discussed the differences and their effect on the content, next we would like to focus on how these differences affect the teacher/learner experience. Among the

[18] Keith, N., and M. Frese. 2008. Effectivness of error management training: A meta-analysis. *Journal of Applied Psychology* 93, 59-69.
Klein, T.A., T.Endrass, N. Kathmann, J. Neumann, D.Y. von Cramon, and M. Ullsperger.2007. Neural correlates of error awareness. *Neuroimage* 34, 1774-1781.
[19] Aldrich, C. 2009. *The complete guide to simulations and serious games*. San Francisco: Jossey-Bass/ Pfeiffer. Barrie, E. 2001. *Meaningful interpretative experiences from the participants perspective.* PhD diss., Indiana University.
[20] Aldrich, C. 2009. *Learning Online with Games, Simulations, and Virtual Worlds*. San Francisco: Jossey-Bass/Pfeiffer.

more obvious differences between the traditional classroom and the highly interactive environments are the new social rules and habits. Together they form a new culture that manifests itself within the practices related to interactive learning. Often these new cultural norms can be confusing or even frustrating to the newcomers, but they represent a fairly minor shift in the student's experience. The following examples illustrate these differences and their new practices.

(A)synchronous Communication

Each generation has its own ways, its own manners, and its own habits. Historically it has been expected that the lecturer will be presenting to an audience that is paying undivided attention. However in the highly interactive virtual/gaming worlds like Second Life it is normal for the audience to chat while attending a lecture. So while a professor may be talking to a hundred students in a virtual room, the students are all talking to each other in the same time. They are using chat to communicate with each other, while listening to the lecture. Most commonly, the chat is pre-created and serves the very purpose of giving the audience the ability to interact while the lecture is in session. Such an approach is normal in Second Life and thus it would be normal in gamification process, but it is still rare in the traditional classrooms.

So is it chaos? No, there are still rules and norms to follow. For example, it is considered rude to chat about topics that are not directly linked to the topic of the lecture. And since the chat windows are relatively small in size, it is perceived as improper to monopolize it. Monopolization can be done in few ways, one is to talk in very lengthy sentences and thus directly take over too much screen real estate. Another example would be repeating of a question that is not being answered by anyone. Such repetitions appear on everyone's screens and tend to annoy all participants.

The next step is to have threaded discussions, where a single lecture may be followed by multiple threaded topics. In such a scenario, each participant may be actively involved in three, five, or any other number of discussions threads, all while listening to the lecturer. While such a practice may be difficult to grasp for some, many of today's students see it as the only way to keep their attention throughout the lecture.

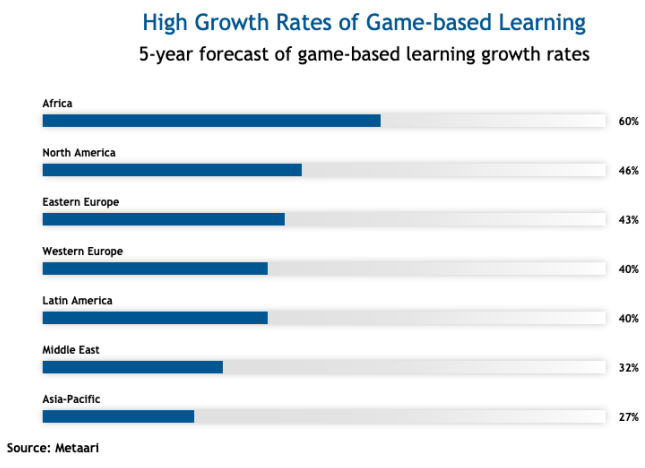
Formulating Emotional States in Explicit Manner

Virtual worlds and video games do not offer the same flexibility in terms of communication, as the face-to-face communication does. Most notably there is a lack of ability to read the other person's body language, as well as no opportunity to hear the tone of someone's voice. So there are virtual chats, but virtual chats rely heavily on typing, and as such must use alternative ways to insure that the message that is being communicated is being perceived correctly. To that end, participants in virtual and gaming environments have

adopted and learned how to make their emotional states explicit. They do so not just through their choice of avatars, but also by utilizing a complex vocabulary of expressions that reflect their mood. The examples of such expressions would be "Great point you made *smiles*" or "Lets get together later *waves*". This can motivate the learners, but also the teachers and move them towards the decision to use video games specifically designed for the process of education in their regular teaching work, not being afraid that usage of video games or virtual environments in the educational process would affect learners' or teacher's ability to express their thoughts and emotions.

Conclusion: Gamification as Future Addition to the Educational Process

The influences of new media and new technologies onto teaching and learning processes, together with the effects they might produce are still a topic to be discussed, and a field to be practically explored. Internet, gaming and virtual environments are developing swiftly, and the possibilities that their platforms enable and offer are yet to be discovered. With the creation of new perspectives within the field of gamification, we can think about the new strategies applicable to educational processes. Their main focus should still be oriented towards teaching/learning motivation, creativity, interpersonal communication and better application of knowledge of both teachers and students. This brings us to the key words of today's educational process merged with technology: communication and cooperation. Communication doesn't relate only to traditional teacher-student dynamics, but is also heavily relying on technology development. One of the most interesting questions would certainly be the way technology opens up new possibilities of communication, education and presence. Contemporary process of education is inseparable from technology, and technological knowledge that young generations possess (especially Millenials and post-Milennials) might be an ideal ground for introducing gamification strategies into an educational process. All of this, for sure, doesn't ignore following questions that would also include the issues of digital literacy of the generations of teachers, the traditional norms of academic contexts in different parts of the world, as well as the issue of Internet/digital tools (un)availability.



However, educational processes are nevertheless continually developing, bringing more and more necessity to open up the question of gamification, virtual worlds and distance learning strategies in the times of technoconnection. Learning processes will surely change, possibly bringing more interactivity, game-like structures and cooperation of all the acters in the field. Highly interactive environments, as gaming/virtual/digital worlds are definitely showing a huge potential and effectivity; but in order for them to be systematically applied in the schooling system, we need to work on the motivation of those who would use it continually. This refers both to teachers, as well as to students and other active agents that might be important for the process: educational institutions, programmers, and digital market developers. The possibilities that asynchronous gaming interactive learning brings also could intrigue educational institutions and motivate them to create study programs open for more students (for example, distance learning students in different time zones, or regularly employed students that find it difficult to adapt their working hours with their classes), or for their specific interests.

All these issues, just lightly touched by this text, are opened up as an incentive to think further about the possibility of using video games and virtual environments in future educational projects and practices. Gamification of education would certainly count into one of those contributions of the future times that we, both as educators and continual learners, would love to see in the years to come.

References

Aldrich, C. (2009). *Learning Online with Games, Simulations, and Virtual Worlds*. San Francisco: Jossey-Bass/Pfeiffer.

Aldrich, C. (2009). *The Complete guide to simulations and serious games*. San Francisco: Jossey-Bass/Pfeiffer.

Barrie, E. 2001. *Meaningful interpretative experiences from the participants perspective.* PhD diss., Indiana University.

Biro, G. I. (2014). Didactics 2.0: a pedagogical analysis of gamification theory from a comparative perspective with special view to the components of learning. *Procedia - Social and Behavioral Sciences, 141*, 148–151.

Clark, R. E. (1983). Reconsidering research on learning from media. *Review of Educational Research, 53*(4)

Clark, R. (1994). Media will never influence learning. *Educational Technology Research and Development*, *42*(2), 21-29.

Dichev, C., & Dicheva, D. (2017). Gamifying education: what is known, what is believed and what remains uncertain: a critical review. *International Journal of Educational Technology in Higher Education, 14*(1), 9. https://doi. org/10.1186/s41239-017-0042-5.

DomíNguez, A., Saenz-De-Navarrete, J., De-Marcos, L., FernáNdez-Sanz, L., PagéS, C., & MartíNez-HerráIz, J. J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & education, 63*, 380-392.

Finn, J. D. (1964). The Franks had the right idea. *NEA Journal, 53*(4), 24-27.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. (pp. 20-20). NY: Pagrave Macmillan.

Holberg B. (1985) *The Feasibility of a theory of teaching for distance education and proposed theory.*(ZIFF Papier). Hagen, Westgermany: Fern Universitat, Zentrales Institute furFernstudienforschungArbeitsbereich. (ERIC Document Reproduction Service No. ED290013)

Holberg, B. (1986) *Growth and structure of distance education* (3rd ed.). London: Croom Helm.

Holberg, B. (1995) *The sphere of distance education revisited.* (ERIC Document Reproduction Service No. ED386578)

Keegan D. (1988) *Theories of distance education: Introduction.* In D. Stewart, D. Keegan & B. Holmberg (Eds.), *Distance education: International Perspective* (pp. 63-67). New York: Routledge.

Keegan D. (1995). *Distance education technology for the new millennium: Compressed video teaching*. (ERIC Document Reproduction Service No. ED389931).

Keegan, D. (1996) *The foundations of distance education* (3rd. ed). London: Croom Helm.

Keith, N., and M. Frese. (2008). Effectivness of error management training: A meta-analysis. *Journal of Applied Psychology 93*, 59-69.

Klein, T.A., T.Endrass, N. Kathmann, J. Neumann, D.Y. von Cramon, and M. Ullsperger. (2007). Neural correlates of error awareness. *Neuroimage 34*(4), 1774-1781.

Ledoux, J. (1998). *The emotional brain*. New York: Simon & Schuster.

Moore, M. (1994) Autonomy and interdependence.The American Journal of Distance Education, 8(2), 1-5.

Squire, K., Barnett, M., Grant, J. M., & Higginbotham, T. (2004). Electromagnetism supercharged! Learning physics with digital simulation games. *Proceedings of the 2004 International Conference of the Learning Sciences*. Los Angeles: UCLA Press.

Wedemeyer, C. (1981). *Learning at the backdoor. Madison.* WI: University of Wisconsin Press