Gamification in engineering education: a pedagogical perspective.

Paciarotti Claudia, Bertozzi Gabriele

* *Dipartimento di Ingegneria Industriale, Università Politecnica delle Marche, Via Brecce Bianche, 12, 60131 Ancona – Italy (c.paciarotti@univpm.it, g.bertozzi@pm.univpm.it)*

Abstract: The implementation of game structure components into genuine circumstances not ordinarily connected with games is what is usually labelled as Gamification. Born in the economical world in order to change customers' behaviour and making the products more appealing, Gamification is rapidly growing in the realm of instruction. Both areas overlap in many respects (motivation, assessing and certifying levels, feedback, practice…) and this made the transfer from one field to the other easier. In engineering studies, which is the context of this research, Gamification is quite a spread out pedagogical model. Nevertheless, Gamification depends on many variables and failure is not an unusual aspect of this methodological implementation. Sometimes considered a tautological autonomous didactic strategy, it is applied with little awareness of its pedagogical implications. Specific aim of this paper is to highlight the existing correlation between gamified features and the correspondent pedagogical evidence-based research or theories in order to prospect new scenarios for teaching processes in higher education.

Keywords: gamification; engineering; pedagogy

1. INTRODUCTION

The use of game design elements in non-game contexts represents the most popular definition of Gamification (Deterding et al., 2011). Even if stemmed from the business world, it is now extending to education, in its broadest sense. For a long time, this model of education has spread to the practical level through its applications, disseminating best practices that have been gradually shared and inherited (Koivisto & Hamari, 2019). Containing within itself many of the elements considered valid for a successful learning process (Hattie, 2008) Gamification has expanded to the point of invading, so to speak, a wide range of disciplines and contents (Hamari et al., 2014). Nevertheless, the research is fairly recent in the academic field and reflects the wide application of the methodology itself (Koivisto & Hamari, 2019). In this way there have been advantages in identifying the characteristic and transversal elements of the model. Studies are mainly concerned with exploring the effects or effectiveness of features belonging to Gamification. However, what this paper proposes is an attempt to draw a bigger picture: a contribution can still be made about the inner pedagogical nature of Gamification. Much of the scientific literature in the field of Instruction already provides answers to a good amount of questions that have been raised in Gamification, with close reference to this article: Gamification implemented in Engineering Education. This is the area of implementation where Gamification is deployed to enhance students' motivation, engagement, learning in context, deliberate practice, commitment (Darling et al., 2008) soft skills, competent inventive and creative critical thinking capabilities and mentality (Bodnar et al., 2016). Our specific interest is in underlying the existing relation between Gamification features and Didactics and consequently guide the professors' decision making process during the design phase related to the choice of specific structural elements. This should hopefully lead to a better insight of teaching processes issues and hence, suggest new and more customizable directions to engineering teachers who, often, do not have a specific pedagogical training (Bodnar et al., 2016).

2. LITERATURE REVIEW

In order to develop this analysis, it is not only necessary to examine studies with special reference to Engineering Education but also to comprise both those which can give us an overall view of what has been done in terms of research on Gamification in general, deriving best practices and pitfalls recognised as such in a transversal manner by experts in the field. Academic studies about Gamification involve many fields, and Education/Learning represents the most relevant one (Koivisto & Hamari, 2019). Both Gamification and Education aim at the acquisition of new knowledge, skills and competence into a related context. Many studies collected in meta-analyses investigated the effectiveness of Gamification in the field of Education (Randel et al.,1992; Hays, 2005; Ke, 2009; Vogel et al.,2006; Stizmann, 2011) showing results in terms of outcomes and motivation in many disciplines. Interestingly enough, it has to be noticed that academic literature refers to levels of effectiveness related to Gamification, but not many failures are reported. On the other hand, Gamification experts report a noteworthy rate of fiascos that reaches up to 80% (Kapp, 2012). Literature often investigates how the gamified experience is perceived and the focus is always on the player, even if there are more than one role to be played (Robson et al., 2015). With regard to specific features of Gamification investigated in literature, a comprehensive analysis can be found in Koivisto & Hamari (2019). Given the general frame, it is now possible to move into the specific engineering literature related to Gamification. As for the articles published from 2000 to 2014 reference is to a systematic review by (Bodnar et al., 2016) while from 2015 onwards to this research. Special focus was put on detecting the pedagogical awareness behind game-based implementations. Taking a look at the specific engineering literature, it can be stated again that the general academic approach to Gamification is that of investigating typical game aspects as for its general implementation, but independently from what is already known in terms of pedagogical research or theory. With regard to a correlation between Gamification features and pedagogy, only few studies could be found with the same urge to underline the strong connection between gamification and pedagogy so to derive new paths of research and a more conscious implementation (Tulloch, 2014). Academic research underlines how, due to the long tradition of lecturing in engineering courses, gamification is mostly deployed to enhance: engagement (Darling et al., 2008), soft skills and a more general creative and innovative problem-solving attitude (Bodnar et al., 2016). Gamification "has been used in engineering disciplines and by far, the published use of games is most frequent in the computer, mechanical, and electrical engineering disciplines" (Bodnar et al., 2016). As to this paper, very interesting is the conclusive comment that Bodnar makes on the literature from 2000 to 2014 in Engineering Education and that is applicable to the literature of the following years: "…game-based learning in engineering education is carried out solely by engineering or affiliated faculty, and not necessarily by engineering education researchers nor in partnership with education faculty. We suggest that engineering educators… consider collaborating with… engineering education researchers or other education" (Bodnar et al., 2016).

3. ANALYSIS

Let's focus now on the most shared constituent elements of Gamification. Since Gamification is represented by a constellation of features (Rodrigues et al., 2019) this research will refer to the role of the "designer" of a gamified instructional model and will consider his or her point of view. Our discussion will be led by a list of the most shared features which are valued both in academic and grey literature as "blue prints" of a gamified structure (Burke, 2016; Kapp, 2012; Koivisto and Hamari, 2019; Bodnar et al., 2016):

Setting (Environment; Goals) - **Engagement** (Cooperative/Competitive/Individualistic) - **Journey** (Avatar/In person; Open/Guided; Segmented; Levels; Feedback; Rewards). Each element will be analysed through a distinct dedicated paragraph.

The question is: is pedagogy capable of showing the theoretical and empirical relations between all these features and their widespread implementation in actual gamified projects? Due to the width of the subjects, they'll be discussed in a summarized way with particular reference to what has already been found in terms of evidence-based research and in the light of the intrinsic connection between pedagogy and Gamification. The development of the discussion will assume the didactic and educational objectives that move teachers to utilize Gamification in Engineering Education as already acquired (motivation, engagement, learning in context, deliberate practice, commitment, soft skills, creative critical thinking). The reflection on the pedagogical and structural aspects will therefore have an implicit reflection on these aspects, clarifying and defining the link with Engineering Education. Before getting into the blue prints of gamification, let's discuss the most general conceptual set where all those typical features are inserted: Player-centric design and Motivation.

3.1 Player-centric design. Gamification experts claim that being player-centred is a fundamental prerequisite to successful game-based practices. In Gamification, even in its commercial implementation, being player-centred means developing a bottom up "design thinking" that takes into account who the player is (target audience) in many respects such as: goals, aptitudes, background (Burke, 2016). The better the designer knows the player the more appealing the game-based design will be. As to knowing engineering students, for instance, academic goal progress, self-efficacy, and environmental supports are strongly valued and predictive of students' academic satisfaction (Lent et al., 2007). The player has to perceive the activity as not mandatory or somehow imposed. Hence, designer's and player's interests have to overlap to some extent and that is the area where Gamification can take place (Kapp, 2012). How a Player-centric design can be translated into pedagogical terms? Game-based experiences can be considered as a teaching/learning process and since "all games are edutainment" (Koster, 2004) then the player corresponds to the role of the student. Hence, claiming that a proper Gamification experience has to do with a player-centric vision, means referring to one of the best known pedagogical concepts: "student-centrality". From a pedagogical point of view, having students as central actors of a learning/teaching process is a multifaceted idea that deals with the cognitive, psychological/affective and social spheres of the learner. All these areas are intrinsically interconnected and aim at the development of an autonomous, competent and socially integrated individual. This concept brings with it a major change of perspective. For a long time and still nowadays in everyday practice, teachers have been considered the main actors of the learning process. In Engineering Education teaching seems equivalent to lecturing (Jochems, 1996). Their knowledge had to be transferred into students' minds independently from their background or interests as if they were "banks of information" (Freire, 2018). Once questioned the traditional approach, new theories and consequently strategies have come to the fore: project/problem based learning, hands-on, active learning, problem solving, inquiry-based learning to mention a few. In their differences, they all share a common social constructivist idea stemming from Vygotsky, Watzlawick; Piaget, and overlaying features: students are challenged on a proximal zone; they are individually or actively engaged and involved in discovering and constructing their own knowledge autonomously or through discussion. Consequently, teachers become facilitators, non-directive creators of learning opportunities and with a generally limited corrective intervention (Daniels, 2001; von Glasersfeld, 1995). To these days, the traditional approach and the constructivist one have been draconically separated and contraposed as if the first had to be held as entirely bad and the latter as the most effective and synonymous of student-centrality. Nevertheless, academic literature seems to contradict this widespread opinion. In fact, going from theories to practice, from theoretical models of knowledge acquisition to effective teaching strategies is not always subsequent (Hattie, 2008). Player/student-centred definition is so re-defined through a set of didactic strategies aiming at guiding, scaffolding and giving feedback (Keller & Sherman, 1974; Adams & Engelmann 1996).

3.2 Motivation. Transversal to all of the structural elements of Gamification and to be intended as a subset of a "student-centred" design, the second major idea in the background is certainly motivation. A motivated player can activate behavioural and psychological dynamics that are functional to the transfer of information (Burke, 2016; Koivisto & Hamari, 2019). In fact, by leveraging Motivation, players/learners show a higher level of engagement, active participation and voluntary practice to mention a few. In addition, there are two ways in which motivation can be defined: intrinsic and extrinsic. The first is based on doing something for its own sake, the second on receiving a reward or avoiding negative consequences (Lepper, 1988). Intrinsic motivation is fostered through challenge, fantasy, curiosity (Malone & Lepper, 1987) control and contextualization (Lepper, 1988; Malone & Lepper, 1987). Vastly investigated in engineering literature (Koivisto & Hamari, 2019; Bodnar, 2016), motivation is contemporarily the goal and the means of all the structural elements listed below.

3.3 Setting (Environment; Goals)

3.3.1 Environment. Determining what the setting of a gamified experience is, means defining the environment where action/learning takes place (Dewey and Bentley, 1949). According to the "Situated cognition theory", mind and body are not separated (Hart, 1996; Crane,2001) and consequently, even less, knowing can be disconnected from the context (Brown et al.,1989). Especially for engineers, knowing is an activity that makes sense in an environment (Barab & Roth, 2006) i.e. the specific one in which knowledge is applied. Therefore, the characteristics of a setting should not be dictated by designers' personal preferences. In fact, just to mention one example, the kind of knowledge that has to be transferred influences the choice. Moreover, the Cognitive Load Theory tells us that an environment is able to recall "schemas" and information already stored in long-term memory (Sweller, 2011) activating an Episodic Memory or behaviourist responses (Gredler, 1992). Choosing among a generic, a detailed or a fantasy (Malone & Lepper, 1987) setting might favour transfer of competences, specific skills and behaviours or information retention, respectively. One last consideration is that, the setting doesn't only refer to the physical scenery, but it is also intended as the social and educational environment where learning happens. In fact, a safe environment is needed and recommended in a learning process. Pedagogy describes it as an environment where, among other things, mistake is welcome and represents an opportunity to get feedback and move forward (Hattie, 2008); in Self-Determination Theory a setting is a "place" where embarking on an activity comes from an internal motivation; a sense of autonomy and competence is perceived (Malone & Lepper, 1987).

3.3.2 Goals. Hence, to venture into this environment requires clear goals, the target has to be in sight, challenging but reachable even if demanding (Hattie, 2008). Setting the goals is a two folded notion and consists of making clear what the learning intentions are and to which level of mastery they have to be learnt: i.e. success criteria (Adams & Engelmann, 1996). They both are claimed by meta-analysis as the most effective teaching tools (Hattie, 2012). Gamification often relies on two different kind of goals: game goals and learning goals. The last ones are generally conveyed through the accomplishment of game goals. In Gamification learning goals are mostly implicit to the action and derived by the player almost involuntarily. The risk here, is to undervalue the importance of a metacognitive reflection: a fundamental element in self-regulation and therefore autonomy. One final thought on the importance of stating clear goals is about the close connection between them and the capacity of students to concentrate on what really matters. This allows to avoid an overload of information and prevents teachers from contradicting the inner non-multitasking nature of our attention (Sweller, 2011).

3.4 Engagement. Engagement is the target that most of game-based teaching aims at and particularly in Engineering Education (Bodnar, 2016). Strictly connected to motivation and the desired consequence of the previous analysed elements and those to come, Engagement may be experimented in many game/learning contexts such as: cooperative, competitive, and individualistic ones. With regard to the second, it has to be noticed that, in the common idea of gamification, it is among the most identifying features of game-based processes. Leaderboards, points, challenges between players are some of the strategies of Game Theory and Competition Based Learning in order to boost students' involvement (Burguillo, 2010). Nevertheless, other Gamification experts, claim that competition, as winner-takes-all mentality (Burke, 2016) is detrimental and this is what could be defined as the misconceived competition mentioned among the most popular pitfalls. Especially in Education/Training the goal is that everybody wins (Kapp, 2012). However, common practice in games suggests a combination of cooperation and competition. But what does evidence-based pedagogy say about it? Competition is profitable when it aims at personal bests or beating curriculum levels regardless of other students' ranking (Hattie, 2012), otherwise it has a negative impact on engagement (Deci & Ryan, 1985). For instance, those who are left behind don't target high goals and diminish motivation (Hattie, 2012). Furthermore, competition can move the focus of engagement away from the learning goal onto strategies of cheating or a transactional mechanism rather than an emotional one (Burke, 2016). Again, it is shown how some shortcomings in Gamification are not due to chance. But engagement, as mentioned above, can be found in a Cooperative learning context too. It is there where it is more effective, especially when contrasted with competitive or individualistic learning. Moreover, studies tell us that Competitive learning outperforms the individualistic one (Hattie, 2008), where individualistic is meant as an individualistic situation, or holding the outcome for others as irrelevant to the attainment of personal outcomes (Johnson et al., 1983). The way students are activated is that typical of a constructivist one and more precisely of the social constructivism with its collaborative and community centred specificity (Kozlowski, 2009). Cooperative learning outperforms Competitive learning in all subject areas, groups - even if not as much in higher education as in other levels of education - and problem solving (Nelson & Skon, 1981; Qin et al., 1995). Most of its effectiveness relies on peers' involvement, since tutoring and being tutored by peers enhance cognitive and social outcomes. Peers can assist in providing social comparisons, emotional support, social facilitation, cognitive restructuring, and rehearsal or deliberative practice (Hattie, 2008). Hence, competition – not the misconceived one - and cooperative can bring results if they are consciously handled and midway solutions can be originated, such as within-group cooperation along with competition among groups tangibly rewarded (Nelson & Skon, 1981). In this way, Gamification practical design advice coincides with pedagogical evidence, but again pedagogical awareness allows a designer/teacher to be more flexible and implement in a more fruitful way them both.

3.5 Journey (Avatar/In person; Open/Guided; Segmented; Levels; Feedback; Rewards)

3.5.1 Avatar. The starting point of a Journey is obviously determining who the "traveller" is. The choice falls between either an in person one or an avatar. Gamification design practice recommends the avatar, i.e. an alter ego, why is it so? The concept of avatar refers to some central instructional models. First of all, that of Modelling part of the "Situated Learning Theory" and claimed as of great effectiveness (Pressley, 2006). It requires the teacher to illustrate and perform a task in the presence of the learner, who can then build a conceptual model from experience. In a way confirmed by the discovery of mirror neurons (Iacoboni, 2009), this theory not only underlines the importance of learning within a social context, but also highlights how being able to view oneself from the outside allows to get feedback and acquire new behaviours and knowledge more easily, in a more emotionally secure and therefore more detached form. In addition, the avatar relates to the pedagogical concepts of metacognition and Microteaching too. The former refers to acquiring awareness of one's own learning process and consequently being able to self-assess and self-regulate; the latter, strictly related to the first, is a didactic strategy which consists in recording and critically reviewing one's own way of acting during a debriefing phase in order to develop new conceptual knowledge and behaviours (Metcalf, 1995).

3.5.2 Open/Guided. The differences between an open and a guided journey might be found in the trajectory the player undergoes to reach a goal, that's to say the nature of the learning processes itself: a constructivist or a mastery one, respectively. With regard to Constructivism, many authors argue that even if minimal guidance might turn into active engagement and motivation to participate, according to the literature it is disadvantageous in terms of learning outcomes. The level of expertise has to be taken into account when dealing with problem-solving-like approaches, since novices might suffer an overload of information (Sweller, 2011). Emblematic is Meyer's invitation to move from the world of ideology hiding under constructivism to the world of theory-based research on how people learn (Mayer, 2004). These critical voices redefine the learning journey drawn by Constructivism. In teaching and learning terms, what does it practically mean? An important contribution comes from the theory of Mastery Learning (Keller & Sherman, 1974) and Direct Instruction (Adams & Engelmann 1996). They state that all students can learn if they know what the goals are, the level of performance that is expected from them and if time of learning is malleable. The way to mastery is paved with a number of strategies: appropriate environment, peer cooperation, frequent and specific feedback generated by formative assessment: a bunch of approaches resulting among the most effective in literature (Hattie, 2008).

3.5.3 Segmented. Segmenting a learning process finds its reasons in the structure of the brain itself. Transferring information from short-term memory to long-term memory requires segmentation of new information in order to avoid cognitive overload and transient information effects (Sweller, 2011). Now segmentation is generally useful but the way it is implemented depends on the internal structure of the piece of information in relation to its complexity or prior knowledge. As to the latter, what is useful for learners with low prior knowledge, might result useless and redundant for those with a higher level of expertise (Spanjers et al., 2010). Segmentation is a sort of facilitating strategy and is strongly related to the following notions of Levels and Feedback too.

3.5.4 Levels. The concept of levels can be declined through different definitions (Kapp, 2012) since they might represent units of information, degrees of difficulty or certification of an achievement. Once a level is completed the player moves to the next. The correspondent pedagogical concept is the so called Proximal Development Zone, that's to say that new ideas can be acquired only if the "distance" from what is already known is achievable. The leap has to be challenging and demanding but still doable. Hence, knowledge is possible when new tasks are tackled but with already enough prior information in order to make sense of the new unknown challenge (Daniels, 2001). Levels help and accompany the progression of the player/learner, skills are both built and reinforced and motivation is boosted (Kapp, 2012). Intending the levels as units of information it is possible to refer to the pedagogical concept of "individualization" (Baldacci, 2005) where all learners are given the chance to reach a common knowledge; by the use of levels as degrees of difficulty, a game can provide "personalization" (Baldacci, 2005) i.e. each learner takes on challenges accordingly to his or her personal capabilities. Levels can be also meant as levels of experience of the player (Kapp, 2012) and, as discussed above about competitiveness, this represents an example of that fruitful competition against one's own bests. One last consideration, is that levels are strictly connected to motivation and feedback too. According to Self-Determination Theory, levels motivate through fostering a sense of competence, autonomy meant as self-efficacy (Deci & Ryan, 1985). On the other hand, feedback is what prevents the Gamification designer from making the wrong choice of Level progression, falling into the common error of creating unbridgeable gaps between skills and challenges (Burke, 2016).

3.5.5 Feedback. Feedback is a central concept in every learning process as it offers the learner the opportunity to be aware, to direct energies towards fruitful paths. Giving and receiving feedback is one of the tools most capable of activating visible cognitive changes (Hattie, 2018). Feedback is a response to a particular action or performance and connects what is known to what has to be learnt (Sadler, 1989). "One of the features" gamification has "over traditional learning contexts is the frequency and intensity of feedback" (Kapp, 2012). Feedback guides, scaffolds the player/learner along the journey and is provided through many forms: comments, cues, reinforcements, tests' results and so on. Nevertheless, designing feedback mechanisms within a game-based project cannot do without a thorough understanding of the type of learning that has to be promoted and, at the same time, of the characteristics of feedback in terms of proven effectiveness. The latter depends on levels of expertise of the learner, timing, possess of prior knowledge and the kind of feedback that is used. Feedback has to be specific and related to the task and associated to three main questions regarding: learning intentions, goals, success criteria; metacognitive skills; future progression. Each question then works at four levels: correctness; procedural; self-regulative; to the self (Sadler, 1989). For instance, the latter, usually praise, is the least effective since it doesn't inform the learner on specific aspects of the task and produces effects of anxiety, disengagement and defence of the self (Hattie, 2018).

3.5.6 Rewards. Points, badges and the whole game economy based on tangible/extrinsic rewards are among the most deployed features in Gamification frameworks in Engineering Education (Garcìa et al., 2017) and appear to have much in common with feedback addressing the self. They reinforce or certify an achievement, but at the same time, not transferring specific information about the task, provide a feedback aimed at the personal level. In literature extrinsic rewards are never connected to improvement of performance, intrinsic motivation, engagement and metacognitive skills enhancement (Hattie, 2018). On the other hand, intrinsic motivation and intrinsic rewards go hand in hand in the so-called game economy. Although more difficult to achieve, intrinsic reward is what creates an autonomous force within Gamification, reducing the risk of exhaustion of motivation to participate on the learner/player behalf. Along with the elements analysed above, intrinsic reward is the key to the materialization of a profitable game-based experience; in a nutshell: learning in a pleasant motivating manner.

4. CONCLUSIONS

Because of its autonomy granted to players and the chance that it offers to actively and willingly approach a proximal zone of knowledge in context, Gamification comprises most of the constructivist features. At the same time, through feedback, segmenting, levels, it counterbalances the weak points of this pedagogical vision with a Mastery Learning and Direct Instruction approach. Moreover, Gamification seems to pursue mostly specific behavioural and cognitive goals. The educational aspect meant as a harmonic personal development with regard to the social, psychological and affective spheres and the still very effective relation with teacher's clarity and credibility, results to be diminished. Unless these aspects are comprised in the goals of the gamified experience itself, Gamification is more characterized as a practical tool. Due to its flexibility and complexity, regardless of the engineering area of application and different levels of materialization (Hakak et al., 2019) Gamification appears to be a very customizable instrument, but its adaptability again calls for specific pedagogical competences on behalf of the instructors in order to make designing decisions. There are, in fact features such as competition, feedback, rewards that might contradict the student-centred vision and have detrimental impact on outcomes and motivation. Among the risks, the following are of particular interest: motivation driven by transactional mechanisms rather than emotional ones; misconceived competition; unbridgeable gap between skills and challenges; mandatory participation; cheating (Burke, 2016). Each single methodology is dependent on contextual elements and teachers' didactic training is among the most relevant ones. Instructional models such as Gamification are hard to design and to manage. This especially applies to Engineering Education, where higher levels of thinking and creative attitudes are pursued: engagement, soft skills, creative ability in problem-solving or open-mindedness. Again, instructors shouldn't approach Gamification as a ready-made tool. Its efficacy depends on precise and pondered decisions that cannot be made without specific didactical knowledge. The tiring and discouraging study and adaptation to new methodologies on behalf of the instructors could be replaced by a more transversal acquisition of knowledge of the most effective evidence-based teaching strategies and their pedagogical foundations. This would allow teachers to develop a more flexible knowhow capable of meeting and focusing on the specific needs of Engineering Education. After all, if the concept of Proximal Development Zone applies to students, reversely teachers too shouldn't approach tasks that create unbridgeable gaps between their prior pedagogical knowledge and what they are meant to know in order to design and manage a new instructional model. As a start, teachers should ask for specific training or promote collaborations with experts in Education, or, step by step, move from traditional lecturing towards more approachable hybrid teaching methodologies.

REFERENCES

Adams, G.L., and Engelmann, S. (1996). Research on direct instruction: 20 years beyond DISTAR. Seattle,WA: Educational Achievement Systems.

Baldacci, M. (2005). *Personalizzazione o individualizzazione?*. Edizioni Erickson.

Barab, S.A., and Roth, W.M. (2006). Curriculum-based ecosystems: Supporting knowing from an ecological perspective. *Educational Researcher*, 35(5), 3–13.

Bodnar, C. A., Anastasio, D., and Other (2016). Engineers at play: Games as teaching tools for undergraduate engineering students. *Journal of Engineering Education*, 105(1), 147-200.

Brown, J.S., Collins, A. and Duguid, P. (1989). Situated cognition and the culture of learning. *Educational researcher*, 18(1), 32-42.

Burguillo, J.C. (2010). Using game theory and Competition-based Learning to stimulate student motivation and performance. *Computers & Education*, 55(2), 566–575.

Burke, B. (2016). Gamify: How gamification motivates people to do extraordinary things. Routledge.

Crane, T. and Patterson, S. (2001). Introduction. History of the Mind-Body Problem. pp. 1–2.

Daniels, H. (2001). Vygotsky and pedagogy. London: Routledge Falmer.

Darling J., Drew B., and Other (2008). Game-based learning in engineering education. International Conference on Innovation, Good Practice and Research in Engineering Education, July 14–16, 2008. Loughborough, United Kingdom.

Deci, E.L. and Ryan, R.M. (1985). Self-determination. New Jersey: John Wiley and Sons Inc.

Deterding, S., Dixon, and Other (2011). From game design elements to gamefulness: defining gamification. Proceedings of The 15th International Academic MindTrek Conference: Envisioning Future Media Environments (pp. 9-15).

Freire, P. (2018). *Pedagogy of the oppressed*. Bloomsbury publishing USA.

Garcia, F., Pedreira, O., Piattini, M., Cerdeira-Pena, A., & Penabad, M. (2017). A framework for gamification in software engineering. Journal of Systems and Software, 132, 21-40.

Gredler, M.E. (1992). *Learning and instruction: Theory into practice*. New York: Macmillan.

Hakak, S., Noor, N. F. M., Ayub, M. N., Affal, H., Hussin, N., & Imran, M. (2019). Cloud-assisted gamification for education and learning–Recent advances and challenges. Computers & Electrical Engineering, 74, 22-34.

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work? -- a literature review of empirical studies on gamification. 2014 47th Hawaii International Conference on System Sciences, 3025–3034.

Hart, W.D. (1996). *Dualism*. in A Companion to the Philosophy of Mind, ed. Samuel Guttenplan, Oxford: Blackwell, pp. 265-7.

Hattie, J. (2012). *Visible learning for teachers: Maximizing impact on learning*. Routledge.

Hattie, J. (2008). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. Routledge.

Hays, R. T. (2005). *The effectiveness of instructional games: A literature review and discussion* (No. NAWCTSD-TR-2005-004). Naval Air Warfare Center Training Systems Div Orlando Fl..

Iacoboni, M. (2009). *Mirroring people: The new science of how we connect with others*. Farrar, Straus and Giroux.

Jochems, W. 1996. "Good Practice, Wat Is de Praktijk En Wat Is Goed? [Good Practice, What Is the Teaching Practice and What Is Good?]." Onderzoek van Onderwijs 25: 4–5.

Johnson, D. W., Maruyama and Other (1981). Effects of cooperative, competitive, and individualistic goal structures on achievement: A meta-analysis. *Psychological bulletin*, 89(1), 47.

Kapp, K.M. (2012). *The gamification of learning and instruction*. San Francisco, CA: Pfeiffer

Ke, F. (2009). A qualitative meta-analysis of computer games as learning tools. *Effective Electronic Gaming in Education*, 1, 1–32.

Keller, F.S. and Sherman, J.G. (1974). *PSI, the Keller Plan Handbook: Essays on a personalized system of instruction*. Menlo Park, CA: Benjamin.

Koivisto, J. and Juho H. (2019). The rise of motivational information systems: A review of gamification research. *International Journal of Information Management,* 45, 191-210.

Koster, R. (2004). *Theory of fun for game design*. Sebastapol, O'Reilly Media, Inc.

Kozlowski, L.M. (2009). *Influence of project based science practices in teaching for diversity*. Columbia University.

Lent, R. W., Singley, D., Sheu, H. B., Schmidt, J. A., Schmidt, L. C. (2007). Relation of social-cognitive factors to academic satisfaction in engineering students. Journal of Career Assessment, 15(1), 87-97.

Lepper, M.R.(1988). Motivational considerations in the study of instruction. *Cognition and instruction*, 5(4), 289-309.

Majuri, J., Koivisto J. and Hamari, J. (2018). Gamification of education and learning: A review of empirical literature. GamiFIN 2018. CEUR-WS, 2018.

Malone, T. W. and Lepper, M.R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. Aptitude, learning and Instruction III: Cognitive and affective process analysis. 223-253.

Mayer, R.E. (2004). Should there be a three-strikes rule against pure discovery learning?. *American psychologist*, 59(1), 14.

Metcalf, K.K. (1995 April). Laboratory experiences in teacher education: A meta-analytic review of research. Annual Meeting of the American Educational Research Association, San Francisco, CA.

Pressley, M., Gaskins, I.W. and Other (2006). A portrait of benchmark school: How a school produces high achievement in students who previously failed. *Journal of educational psychology*, 98(2), 282.

Qin, Z., Johnson, D.W. and Johnson, R.T. (1995). Cooperative versus competitive efforts and problem solving. *Review of Educational Research*, 65(2), 129–143.

Randel, J.M., Morris, B.A. and Other (1992). The effectiveness of games for educational purposes: A review of recent research. *Simulation & Gaming*, 23(3), 261–77.

Robson, K., Plangger and Other (2015). Is it all a game? Understanding the principles of gamification. *Business Horizons*, 58(4), 411-420.

Rodrigues, L.F., Oliveira, A. and Rodrigues, H. (2019). Main gamification concepts: A systematic mapping study. *Heliyon*, 5(7), e01993.

Sadler, D.. (1989). Formative assessment and the design of instructional systems. *Instructional science,* 18(2), 119-144.

Spanjers, I.A.E., Van Gog, T. and van Merriënboer, J.J.G. (2010). A theoretical analysis of how segmentation of dynamic visualizations optimizes students' learning. *Educational Psychology Review*, 22, 411–423.

Stizmann, T. (2011). A meta-analytic examination of instructional effectiveness of computer based simulation games. *Personnel Psychology*, 64(2), 489–528.

Sweller, J., Ayres, P. and Kalyuga, S. (2011). Cognitive load theory. Springer, New York, NY.

Tulloch, R.. (2014). Reconceptualising Gamification: Play and Pedagogy. *Digital Culture & Education,* 6(4).

Vogel, J.J, Vogel, D.S. and Other (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research*, 34(3), 229–43.

Von Glasersfeld, E. (1995). *Radical constructivism: A way of knowing and learning*. London: Falmer Press.